S. Hrg. 103–602

HARMFUL NON-INDIGENOUS SPECIES IN THE U.S.

HEARINGS

BEFORE THE

COMMITTEE ON GOVERNMENTAL AFFAIRS UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

SECOND SESSION

MARCH 11 AND 15, 1994

Printed for the use of the Committee on Governmental Affairs

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FRIDAY, MARCH 11, 1994

U.S. SENATE,
COMMITTEE ON GOVERNMENTAL AFFAIRS.
Washington, DC.

The Committee met, pursuant to notice, at 10:10 a.m., in room SD–342, Dirksen Senate Office Building, Hon. Daniel Akaka presiding.

Present: Senator Akaka.

OPENING STATEMENT OF SENATOR AKAKA

Senator AKAKA. The Committee on Governmental Affairs will be in order. Welcome to our guest witnesses here today. We welcome all of you to this hearing. Aloha and good morning!

Today's hearing will focus on the problems that alien species pose to our Nation's agriculture, environment, and economy.

The United States is being subjected to a slow, silent invasion of alien pests. These invaders hitchhike aboard planes, lurk in old tires, hide in household goods, and swim in the ballast of ships.

We have a pie chart [1] that helps us illustrate this point. Using Hawaii as an example, we can see that alien species use every conceivable mode of transportation to invade our State.

Developing loss estimates due to alien species is inherently difficult. Studies place annual losses to U.S. agriculture, forests, rangeland, and fisheries in excess of $100 million. During high-impact years, losses increase to several billion dollars.

Alien pests represent a serious threat to many, many areas of economic activity. Agriculture must contend with an array of alien weeds, insects, and pathogens. A significant portion of the $7 billion that farmers spend annually on pest control is applied to contain alien species.

Some weeds do not directly harm agriculture, but serve as hosts for agricultural pests instead. For example, crested wheatgrass, which was once planted for soil conservation, harbors the Russian wheat aphid. This pest caused $170 million in losses during 1988 alone.

Chestnut blight, which arrived on diseased plantings from China, killed over a billion chestnut trees during the early part of the century. Another forest threat, the gypsy moth, was responsible for $760 million in losses during peak years.

[1] See page 138.

Hydrilla is the scourge of Eastern waterways. This aquatic weed blocks irrigation and drainage canals, promotes sedimentation in flood control reservoirs, impedes navigation, and suppresses fisheries. $100 million is spent annually to control this and other aquatic pests. Aquatic nuisances such as zebra mussels and Asian clams regularly clog municipal water lines and irrigation pipes.

But nowhere are the effects of alien species more dramatic than in Hawaii. The September 1993 Office of Technology Assessment report concluded that few economic or non-economic activities in Hawaii are unaffected by the influx of alien pests. The Aloha State is a case study of what happens when alien pests run wild.

Hawaii receives an average of 18 new pests annually. This is more than a million times the natural rate and more than twice the number absorbed each year on the mainland. The lack of a winter frost means that these uninvited guests multiply all year long. Hawaii has no aloha for these noxious pests.

Faced with a steady invasion of alien pests, it is no wonder that the State's environment has been overwhelmed. Ten percent of Hawaii's plant species are already extinct, and about 30 percent of those that remain are threatened or endangered.

Hawaii has become a magnet for the world's noxious pests. Because of intentional and accidental introductions, alien pests such as banana poka, fire tree, army worm, five species of fruit fly, and a host of feral animals impose a tremendous burden on our economy and our environment. The list goes on and on.

I recently received a letter [1] from Hawaii's Outdoor Circle asking that I investigate a new threat, the ivy gourd. According to their letter, this pest is growing out of control on the windward side of Oahu. The list of Hawaii's alien species seems to get longer each day.

We also have a healthy fear of pests that have yet to reach our shores. The arrival of the brown tree snake would be an obituary for Hawaii's native forest birds.

Alien pests do not just compete with native species; they dramatically alter the landscape and change the rules of the game by which native species live. As a result, we are rapidly losing our living heritage of plants and animals that constitute the foundation of biological diversity.

Due to the explosive growth in commerce, tourism, and travel, the army of invading pests is on the rise. Hawaii is a good example of this trend. A 50 percent increase in air traffic during the 1980's made Honolulu the 15th busiest airport in the Nation. Pests arrive as stowaways in transportation equipment and cargo. Plants and animals are brought in, intentionally or unintentionally, by the increasing numbers of travelers.

Even our own residents are to blame. In February 1992, the Hawaii Department of Agriculture sponsored a 1-week amnesty program for residents to turn in illegal animals. The campaign netted 53 animals, including various snakes, reptiles, and amphibians, as well as harvester ants, hamsters, and birds.

Experience in Hawaii and elsewhere demonstrates that we have no effective national policy to combat the threats of alien pests.

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[1] See page 139.

Federal and State initiatives simply are not keeping pace with new and spreading alien species. The recent OTA report echoes this concern. It found that our country has no real national policy for controlling harmful alien species. The current system is piecemeal, lacking adequate rigor and comprehensiveness.

The charts [1] on display (here on your right and my left) illustrate these points. The first is a list of Federal agencies with alien species responsibility. It shows that 24 Federal agencies are responsible for some aspect of research, prevention, control, or use of alien species. The list, as you can see, is very long.

The second chart shows the interrelationship among all the major interests—Federal, State, industry, academia, and the general public—that affect alien species policy.

The question for Congress to consider is how to achieve a more stringent and comprehensive national policy on harmful alien pests. I hope today's witnesses will offer their recommendations on how to improve on the current system.

I ask that the witnesses limit their testimony to 5 minutes to provider greater time for discussion. Your written statements will be entered into the record in their entirety, and there is no need to read from a prepared text. The hearing record will remain open until the close of business April 11, 1994, to receive comments from individuals and organizations not present today.

At this time I am delighted to have a panel of experts. First is Dr. Dewey Caron, Department of Entomology and Applied Ecology, University of Delaware; Mr. Don Schmitz, Wetland and Upland Forest Alien Plant Coordinator, Florida Department of Environmental Protection: Mr. Howard Singletary, Director, Plant Industry Division, North Carolina Department of Agriculture; and Dr. James Carlton, Director, Maritime Studies Program, Williams College-Mystic Seaport.

We are delighted to have you here and look forward to your testimony. Let me call on Dr. Caron first.

TESTIMONY OF DEWEY M. CARON, PH.D.,[2] PROFESSOR OF ENTOMOLOGY, DEPARTMENT OF ENTOMOLOGY AND APPLIED ECOLOGY, UNIVERSITY OF DELAWARE

Mr. CARON. Thank you, Senator, and good morning.

I would like to talk a little bit this morning on Africanized bees. Africanized bees are a very special circumstance of a non-indigenous population of organisms, insects, that have spread naturally into the United States. They are currently occupying three of our Southern States: Texas, New Mexico, and Arizona. But it also represents an alien species that there is a continuing need for intercept activities, and, in fact, that activity is ongoing, above and beyond where the population is existing and spreading naturally. We do not know the eventual final distribution of what that population will be within the United States of Africanized bees. We believe it will be considerable.

Coping with that population now, we have a large conglomerate, all of the agencies or nearly all of the agencies that you have listed

[1] See pages 140 and 141.
[2] The prepared statement of Mr. Caron appears on page 69.

in your opening comments, plus State agencies as well. We had a situation with this particular population with the lead Federal agency of perhaps not making up its mind as to what role it would play in a population both spreading naturally into the Southern United States and a need for an intercept. And for that reason, there was a bit of some difficulty at the beginning as the population moved into the United States.

On page 7, I offer some considerations. You asked that we offer some of our comments as to what the future may be. I would like to highlight four of those.

Because of the nature of the problem with the Africanized bees, we need Federal involvement beyond the current level. There is a number of the agencies that are listed, as you indicated in your opening comments, that are now involved, and, of course, there is a need for better coordination. There is the need for both research, extension activities, and educational efforts with the Africanized bee. As I indicated, all of these need to be expanded.

The target audience includes both our industry beekeepers and those that benefit from our industry, those crop producers that need pollination services, but also the State, county, and municipal authorities, both elected and non-elected, that must deal with this alien introduced species, and, of course, the general public that must now face accidental encounters with the defensive behaviors—that is, the stinging—of Africanized bees.

A high priority, as I see it, for dealing with Africanized bees is to reduce the man-assisted movement of the Africanized bee genetic material while protecting the availability of honeybee colonies for pollination of crops and allowing beekeepers a reasonable opportunity to pursue their business or hobby interests. This does, indeed, represent a formidable challenge in contradiction to how the situation with the parasitic bee mites and tracheal mites and introduction of other alien insect species, some of which you mentioned in your opening statement, have functioned.

Possible ports of entry and isolated geographical enclaves such as the Islands of Hawaii and Puerto Rico need continued interdiction efforts and continued destruction of accidental invaders. This has served a useful purpose in the past, and we need to have this continued. Since the population of Africanized bees is both external to our shores and also currently within the three States I mentioned, and likely to continue to spread into additional U.S. territory, the possibilities of man-assisted spread of the genetic material—indeed, the whole population—has expanded, therefore making the task more difficult.

We need Federal assistance in our efforts to help monitor the spread of the Africanized bee population within the U.S. There are a number of agencies that are currently doing that. We have a problem with this population in ID; that is, identification of the bee. USDA ARS assists in Africanized bee identification and performs a service of ID intercepts of the APHIS intercepts. As I indicated earlier, USDA APHIS initially assisted with trapping swarms at monitoring stations in south Texas—they established a fairly lengthy line of stations at 1-mile intervals—but has now withdrawn. It is unclear, at least to many of us outside of the Federal Government, what role APHIS would assume after the Africanized

bee population reached the U.S. This in part hampered other governmental and non-governmental agencies for establishing their territories as part of the solution puzzle, due to this major player holding a stage it eventually has seemingly abandoned. Assistance in the form of a cooperative trapping program or, as a minimum, I suggest, purchasing of traps and pheromone lures making them available to others that will do the trapping mainly by State departments of agriculture are recommended.

The next two recommendations are those that speak to research and education. I have already mentioned those. Let me skip to the next one on the ninth page of my prepared text.

The mechanism that seems to be most effective in reducing man-assisted movement of Africanized bees is establishment of a regulated zone. So far this has been done only in Texas which had in place an action plan to deal with the Africanized bee before its arrival. Now with multi-state distribution, we need more Federal involvement. A national conference cosponsored with USDA and NASDA in 1991 was directed toward development of a national certification and regulation. How are we going to deal with this population, a plan of that nature? Now seems an appropriate time to, again, get all segments of our industry together with governmental and research agencies, both those that are directly involved with bees and those not, to listen to what is working in Texas and develop a workable, effective national action plan for Africanized bees.

Thank you for the opportunity to present these comments.

Senator AKAKA. Thank you very much, Dr. Caron. Because there is a vote in progress, I am going to ask that we break for about 10 minutes. The Committee will be in recess subject to the call of the Chair.

[Recess.]

Senator AKAKA. The Committee will be in order.

I have a statement from Senator Lieberman which I ask to be printed in the record. We certainly appreciate his contribution to the hearing, and other Senators may have statements as well. If they do, we will include them in the record.

PREPARED STATEMENT OF SENATOR LIEBERMAN

Thank you, Mr. Chairman. I know the general subject of endangered species and the specific subject of nonindigenous species is one that you've taken great care with, and I appreciate your leadership and your efforts to elevate the debate on these matters.

I regret that prior scheduling commitments will prevent me from staying to hear the full testimony of today's witnesses, because I, too, care deeply about this topic. The Senate Environment and Public Works Committee on which I serve will begin the process this year to reauthorize the Endangered Species Act. The issue of nonindigenous or exotic species should be addressed then, as well.

I'm particularly glad to welcome Dr. James T. Carleton today. Dr. Carleton's work at the Mystic Seaport will benefit not only Long Island Sound, but all our coastal waters.

Dr. Carleton will talk later about the zebra mussel invasion and its cost to the Great Lakes Region and the Hudson River. I won't belabor our concern that it may yet reach Long Island Sound. But there are two examples specific to Connecticut that I think of when I think of invasive species.

The first is fragmites. It looks pretty, when seen from a passing car on I–95, waving cat-tail like, over a tidal pond. In truth, it's an invader, choking the coastal tidal wetlands along Long Island Sound, driving out native species, preventing those wetlands from delivering their full functional value—as filters for pollution, as nurs-

eries for shellfish and finfish, as critical habitat for migratory waterfowl and endangered species.

The second is a terrestrial example. Our State Department of Environmental Education tells me that Connecticut's forests have been assaulted by "an escalating array of exotic organisms over the last 150 years." This is from a letter I received recently from Eric Thomas, one of the State's Environmental Analysts, "Most of the majestic and widely planted elms have succumbed to Dutch Elm Disease; the American Chestnut once *dominated* Connecticut woodlands, but now only remnants survive the Chestnut blight; and chronic attacks continue on white pine, hemlock, beech, dogwood and several other species that comprise our native woodlands."

In the end, it is not only the functional or economic value that we lose when exotics take over. We lose all the aesthetic values we associate with biological diversity. I'm always struck by this when reading journals of 100 years ago, how different the landscape looked then, how diverse the natural world, and I wonder in what way our lives our diminished by that loss—of diversity, but also of our natural ties to history. I look forward to studying the testimony presented today. Thank you.

Senator AKAKA. At this time, I would like to call on Mr. Don Schmitz for his testimony.

TESTIMONY OF DON C. SCHMITZ,[1] WETLAND AND UPLAND FOREST ALIEN PLANT COORDINATOR, FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION, TALLAHASSEE, FL

Mr. SCHMITZ. Thank you, Senator, and good morning.

Try to visualize with me for a few moments that unique ecosystem in south Florida known as the Everglades. Picture in your mind its large expanses of native sawgrass, its beautiful tree island hammocks, its slow, vast southern sheet flow of water, its rare and endangered wildlife—the snail kite, the Florida panther, and the American crocodile. Visualize the millions of birds that call this ecosystem home. Try to understand the importance of this ecosystem with its biodiversity, not only to the fish and wildlife but to the citizens of southern Florida who depend on its water for life. Without it, the magnificent Florida Bay becomes an aquatic desert, too salty to be a nursery for millions of marine organisms that are so vital as a food source for both wildlife and humankind. And, finally, try to visualize the economic importance of this unique place, not only for its natural resources but for its importance as one of the prime tourist destinations in all the world. It has been designated a world heritage site, international biosphere reserve, and wetland of international importance.

Now, with this picture firmly in mind, picture, if you will, a fleet of gigantic bulldozers slowly crawling their way across the vast expanses of the Everglades. As they move, they destroy everything in their paths. The wetlands are filled in, the waters are drained, the birds and animals are driven out, and their food sources are forever lost. Imagine, if you can, this slow and certain armada completely destroying the Everglades in the course of a few short years. This scenario is the equivalent of what is happening in the Everglades at this very moment as a result of the invasion by the alien melaleuca trees.

The Australian melaleuca tree was first imported around the turn of the century in Florida, and it was imported for its swamp-drying capabilities. In 1990, the South Florida Water Management District estimated that melaleuca was spreading at a rate of 50 acres per day, and that was assuming a linear growth rate. And

[1] The prepared statement of Mr. Schmitz appears on page 73.

we know that it is not linear. The growth rate is exponential. There is a complete displacement of native vegetation when melaleuca invades into an area, and that results in a catastrophic loss of wildlife diversity. It uses four times the amount of water that native sawgrass communities use, and the melaleuca populations that are expanding in the Everglades threaten the Biscayne aquifer, which is the sole underground drinking water source for millions of people who live in south Florida.

If we do not do something about this melaleuca invasion in Florida, the melaleuca populations will destroy what Marjorie Stoneman Douglas called "the river of grass," despite past and present efforts to preserve it for future generations.

More than 900 species of alien plants have become established within Florida's habitats. The majority of them are found in Florida's wetland and upland forests. One-half were imported as landscape ornamentals, contaminants of agricultural practices, or as future sources of timber, fiber, and forage. In the early part of this century, even Federal agencies helped spread these invasive alien plant species around. Present estimates indicate that more than 2.5 million acres of Florida's remaining natural environment has become infested or infected with alien plant species. These invasions can alter ecosystems from once highly diverse biological systems to bland, monospecific structures.

Most Floridians, as is the case with most Americans, are unaware of the severe ecological damage that these invasive alien species are doing in Florida's remaining natural areas. Alien trees are destroying what little remains of our fragile beach dune communities, with negative repercussions on endangered and threatened sea turtles. They cannot nest because of the dense root systems that some of these plant species produce out into the surf area. Hydrilla, which you mentioned in your opening speech, clogs at least 75,000 acres of our waterways. Besides these species, there is another additional 27 exotic plant species that have been identified as being destructive or invasive into Florida's environment.

Because of a lack of funding, we are only capable of managing one-half of the melaleuca populations found in the Everglades. Federal land management agencies in Florida do not have a dedicated funding source to go out and manage these destructive species, nor can they adequately fund long-term solutions such as biological control research.

The State of Florida applauds the efforts by the State of Hawaii to protect their island State from alien species invasions. However, this is not an exclusive problem for just Hawaii and Florida. Purple loosestrife, the contaminant of European ship ballast, has ruined millions of acres of wetlands in the northern United States. Of course, I think all of us have heard of kudzu that has spread throughout the South. The net result is that there is a drastic decline in biodiversity when these invasions occur.

Now, what can the Federal Government do about this problem? First, we need to turn off the spigot of new invasive alien plant and animal species. It does not make a heck of a lot of biological or economic sense to go out and manage these species when you have new ones that are being introduced. We need to screen all potential introductions for their invasiveness, whether they are plant or ani-

mal species. Presently, the way the Federal Noxious Weeds Act is applied is ineffective. For example, it took us 10 years to get melaleuca listed as a Federal noxious weed, and the USDA refused for a number of reasons, despite that we had the entire Florida congressional delegation and the Governor of Florida who requested the USDA to list this species as a Federal noxious weed. If it was not for Congressman Clay Shaw from Fort Lauderdale, I am sure melaleuca would never have been listed.

Secondly, no one is in charge. We need a lead Federal agency. In Florida, we have coordinated our efforts rather well. We have coordinated between the U.S. Fish and Wildlife Service, the National Park Service, and State and county land management agencies, and we have coordinated very well. But in our experience, if no one has the responsibility for this, the work just ultimately does not get done.

Thirdly, the State of Florida endorses the proposed changes to the Federal Noxious Weeds Act that have been put forth by the Weed Science Society of America and the Natural Resources Defense Council.

In conclusion, billions of dollars have been spent in the United States to buy environmentally sensitive areas to protect them from pollution and development, yet the biological heritage to be preserved for future generations is being overrun and lost to non-indigenous species. This is especially true in Florida.

Thank you.

Senator AKAKA. Thank you very much, Mr. Schmitz, for your testimony.

I would like to call on Howard Singletary for your testimony at this time.

TESTIMONY OF HOWARD M. SINGLETARY, JR.,[1] DIRECTOR, PLANT INDUSTRY DIVISION, NORTH CAROLINA DEPARTMENT OF AGRICULTURE, RALEIGH, NC

Mr. SINGLETARY. Thank you, Senator Akaka.

Before I get started, I had a phone call from Dr. Lyle Wong of the Hawaii Department of Agriculture yesterday, and I told him that I was going to be appearing here today. He had indicated that they had sent testimony to be included in the record and asked me to extend his greeting to you, sir.

Senator AKAKA. Thank you very much.

Mr. SINGLETARY. I would like to thank you for the opportunity to appear here before you and testify about the significant impact of the introduction of non-indigenous species, both plants and animals, to the United States and directly as it relates to North Carolina. My comments today will represent the State of North Carolina, the Weed Science Society of America of which I have been chairman of the Federal Noxious Weeds Committee, the Intermountain Noxious Weed Advisory Council, and the National Plant Board. The Intermountain Noxious Weed Advisory Council is a voluntary organization with membership from public and private sectors mainly representing Western States here in this country, whose function is to serve as a liaison between States, Congress,

[1] The prepared statement of Mr. Singletary appears on page 74.

Federal agencies, and trade associations on issues regarding noxious weeds. The national Plant Board is the organization of plant pest regulatory agencies from the 50 States and the Commonwealth of Puerto Rico. That is the background from which I would like to speak to you today.

There are at least 4,500 species of foreign origin that have established populations in this country. Many of these non-indigenous species, including wheat, soybeans, and cattle, have played a significant role in the development of U.S. agriculture. Indeed, much of the economic and food and fiber production in this country is based on introduced species. However—and this is an important however—approximately 15 percent of the non-indigenous species have been documented to cause harm here in this country. That is information from the OTA report.

The economic, health, and environmental costs due to the presence of plant pests are staggering. I would like to highlight for you just a few examples with emphasis on weeds and insect pests in agriculture and forestry.

Weeds compete directly with agricultural crops by reducing quantity and quality and increasing overall weed management costs. And if you had to look at the most costly factor in agricultural production today, weed control is that factor, and where more chemicals are used. According to the estimates derived from the Weed Science Society of America, "Crop Losses Due to Weeds"—this is a publication that they produce, and I am quoting from the 1992 edition—losses directly attributable to non-indigenous weeds are estimated to range from $3.6 billion to $5.4 billion annually. This calculation does not include environmental, health, regulatory, or other indirect costs associated with non-indigenous species, and that is projected to be approximately $1 billion annually.

Now, let me move to a couple of examples, and some of these have been alluded to already, and I will cut short those parts of the references. Witchweed, Striga asiatica, is a semiparasitic plant that attacks corns, sorghum, and sugarcane, reducing yields, and because of its presence, restricts the movement of commodities to other areas in this country and the world. This was a non-indigenous species identified in the 1950's on approximately 430,000 acres in North and South Carolina. There has already been spent in excess of $150 million of Federal funding to eradicate this pest. Fortunately, I can report to you that that acreage is down to 38,000, and we can see the light at the end of the tunnel in terms of the potential elimination of this non-indigenous species. That is just one example of a weed.

You have already mentioned fruit flies in your opening comments, Senator, and Hawaii and California are all well aware of that impact. I will go on.

You also mentioned the European gypsy moth in your opening comments, but I would like to raise a new threat posed by the gypsy moth, and that is the Asian gypsy moth, which is a strain of gypsy moth present in Russia and now parts of Europe. The alarming fact about this particular pest is the fact that the females fly, which means that it has a whole new means of dispersal. The present European gypsy moth established in this country does not fly. Females of the Asian gypsy moth can fly up to 25 miles, docu-

mented. So in terms of spread impacts on forests and urban areas, this is a whole new threat.

I could say that in North Carolina we have been blessed by a recent introduction of this. You understand how I mean "blessed," believe me. It was introduced on munitions brought in by the military at the Sunny Point Ocean Terminal near Wilmington, North Carolina. To eradicate this introduction, it will cost approximately $9.45 million over 3 years.

The Secretary last week, the Secretary of Agriculture, issued an emergency declaration, and we have got that project underway. That is just the tip of the iceberg in what a typical introduction can cost and cause.

On a national level, laws and regulations addressing non-indigenous species are disjointed, and you have mentioned that in terms of 24 agencies here in your chart. I think 21 of those agencies actually have regulatory oversight as it relates to non-indigenous species. In the current scheme, one specific agency may have responsibility for control or eradication programs while others address movement into the United States or interstate movement. This patchwork of agency involvement has prevented, in many cases, a prompt and timely reaction to the introduction of non-indigenous species, thus allowing a prime opportunity for their full establishment and subsequent spread. A good example is the Africanized bee, which has been referred to in terms of action and who has responsibility.

In order to address problems of non-indigenous species, there must be a coordinated effort at the Federal level to identify pest problems at an early stage and prevent their entry. I think there needs to be definitely a more cohesive, organized relationship among these agencies and functions. I am not sure that a lead agency is the complete answer, but there needs to be definitely more of a coordination and emphasis on this function.

One of the things that is paramount to being able to do anything as it relates to this is a solid base of funding, and that is the very first thing that slows an effort when we have a new introduction that needs an effort. You have to go hunt money. There is never a resource there to effectively deal with these situations.

For example, the Animal and Plant Health Inspection Service has a contingency fund of $3 million. Well, Senator, you are familiar with what just one introduction of Medfly costs. One introduction of Medfly here will drain that fund right there. There needs to be a stronger funding base and an emergency fund of large enough significance so that it can be drawn on, possibly that needs to have multi-agency access. I do not know exactly the best way to organize that, but that is a major drawback.

Policy issues as outlined in the recently released OTA report and by the USDA PPQ Weed Policy Steering Group in their departmental recommendations represent a shift to a more holistic approach in reacting to the introduction of non-indigenous plant and animal species in the United States. One area that cries out is the issue of funding, particularly in the area of noxious weeds, and that is where I would like to place my emphasis today.

Considering the full impacts of non-indigenous species, weeds have far more impact from an economic perspective, which I have

already mentioned, on agricultural and natural ecosystems. Presently, they receive less attention because they do not creep, crawl, or fly, and in many cases they take longer to establish. Their initial appearance is less dramatic, but when they begin to proliferate, believe me, they have the most significant economic impact.

In the near future, I hope there will be cooperation in Congress to revise the Federal noxious weed law, granting full authority to react promptly to the introduction of non-indigenous weed species. Without careful and deliberate attention, I feel that the rich plant and animal diversity so much a part of our natural habitats will be lost to non-indigenous species. I urge you as Members of Congress to review these issues and take appropriate actions, and I certainly think that the OTA report provided to you, Senator, has an excellent blueprint in where to start and specific good policy options, I think, that are well founded and have been well thought out and are generally supported.

Just to summarize in terms of recommendations that I would make, again, emergency funding options; emphasis on exclusion and early detection; prompt intervention channels. And I think that investments in these, plus an emergency response fund of some type will save money in the long run. In other words, I think if you make a sizable investment now, that will indeed save money in the long run for the citizens of this country. I think that would lead to an improvement of quality of life and protect the environment here in this country.

We have been working from the weed science perspective in the other agencies that I represent in terms of getting a rewritten version of the Federal noxious weed law introduced in the Congress. Representative Charlie Rose from my home State of North Carolina has agreed to make that introduction on the House side. We have been working during the last year with Senator Dorgan from North Dakota, and hopefully through efforts of his staff it will be introduced on the Senate side. And I would urge your support in this, and I can assure that the State of Hawaii, the Department of Agriculture supports the rewritten version that we plan to have introduced for your consideration through these channels.

Thank you very much for the opportunity to offer these comments, Senator.

Senator AKAKA. Thank you very much, Mr. Singletary.

I would now like to hear from Dr. Carlton, and want you to know that Chairman Glenn of this Committee is very interested in your testimony. Senator Glenn has been responsible for legislation addressing zebra mussels and other aquatic pests, and wanted you to know of his interest. May we hear from you now, Dr. Carlton.

TESTIMONY OF JAMES T. CARLTON, PH.D.,[1] DIRECTOR, MARITIME STUDIES PROGRAM, WILLIAMS COLLEGE-MYSTIC SEAPORT, MYSTIC, CT

Mr. CARLTON. Thank you, Senator. Good morning and thank you for inviting me.

On September 8, 1993, a coal vessel (a collier) arrived in Chesapeake Bay a few miles from this room, having sailed from Israel

[1] The prepared statement of Mr. Carlton appears on page 76.

2 weeks earlier. Our research team boarded this vessel and opened up a hatch to the cargo hold, which was filled with ballast water from the Mediterranean. A school of 50 fish swam by. The fish was called a jack, and it turned out to be a species which had invaded the Mediterranean from the Red Sea through the Suez Canal. This ship released all of these fish, and many more, into Chesapeake Bay.

On September 15, 1993, a bulk cargo vessel from Liverpool arrived in Chesapeake Bay. In her hold was another fish known as a sprat, and here, too, a school of 50 fish were seen swimming in the ballast water. All of these fish, and many more, were released into the bay.

Had someone proposed to intentionally introduce these fish, for whatever reason, many trees would be needed to produce enough paper for the required environmental impact statement. Having been written, the proposal would have been rejected anyway, and yet these fish were released in Chesapeake Bay because they were in a ballast tank and not in a fish tank.

Our aquatic communities—our rivers, our lakes, estuaries, bays, ports, salt marshes—are now being invaded by a host of exotic organisms in a biological game of ecological roulette. No State in the United States is immune to future invasions—invasions that include predators, competitors, and diseases. These same regions support important fisheries, navigation, and recreational resources that are clearly worth billions of dollars.

In most cases, exotic species do not come to our attention because they appear to have no immediate and profound human impact. But this means that the mechanisms that bring these species to us continue unabated, and with every hourly spin of the exotic species roulette wheel, a non-indigenous animal or plant with a vast potential for altering our society could be released.

Our world changed dramatically on June 1, 1988, when the zebra mussel was discovered in the Great Lakes. The mussel came from the Black Sea in ballast water. This was a discovery of such significance that much of our activity in non-indigenous species can be dated as BZM or AZM, before or after zebra mussels.

The year is now 6 AZM, and this mussel has become the watch animal of American waters under the assumption that no new invasion will eclipse it. Thanks to the Non-Indigenous Species Act, we are now regulating the ballast being released in the Great Lakes. Most of our great rivers and all of our coasts remain vulnerable this morning.

Ships today are one of the greatest transporters of the world's aquatic life, carrying tens of millions of gallons of ballast water and within them an immense diversity of life. Thousands of species are in motion around the world, and hundreds and hundreds of species are headed as we speak to the United States.

In 1990, an aggressive omnivorous European green crab appeared in San Francisco Bay where it now occurs by the tens of thousands. The green crab's diet includes commercially important clams, other crabs, including perhaps the native Dungeness crab, and a vast number of other species. It would be hard to find, if we had searched the world, a more potentially devastating species.

One of the most spectacular invasions of all is now occurring in the Black Sea, courtesy of an American species of comb jellyfish, transported by ballast water. It is the revenge of the zebra mussel. Blooms of hundreds of millions of tons of the comb jellyfish have led to a nearly complete decimation of the anchovy fishery in the Black and Azov Seas. One single species has managed to completely alter the food web of one of the world's greatest inland seas. This was, of course, in a country far away, but it teaches us what could happen tomorrow in the Chesapeake Bay or Puget Sound.

Every 60 minutes almost 2 million gallons of aquatic life in ballast water from foreign parts are released in U.S. waters. Will a new invasion occur in the United States in the next few weeks or few months? Absolutely. Will the next invasion be a problem, a catastrophe? Again, it is a spin of the wheel. It may be a small fish. It may be an innocuous worm. It may be another zebra mussel. I urge your careful attention.

Thank you.

Senator AKAKA. Thank you very much, Dr. Carlton.

I now have some questions for the witnesses. Dr. Caron, you mentioned an apparent shortage of bee colonies may prevent current and future pollination needs. To what extent is this problem caused by harmful alien pests, and how will this affect the agricultural and horticultural sectors of our economy?

Mr. CARON. Thank you. Yes, the introduction of the alien mite pest—there are two involved; I mentioned both of them, the veroa and the tracheal mite—is indeed a very serious threat to our industry. These are imports that came accidentally in the middle 1980's and now have caused an apparent shortage in availability of bee colonies for pollination purposes. Coupled with the arrival of the Africanized bee, we expect disruption in the availability of bee colonies to a number of our major crops.

We could live without honey. We could live without the other products from bee colonies. We have alternative sugar sources. But we cannot live with the pollination services of honeybees and our many native species of bees that assist.

We rely on our honeybees that we can move. We can put them on trucks and move them into the pollination situations, and for this reason we need and must maintain a healthy, sufficient population of bees for this pollination service.

The three factors of the mites, the two mites and the Africanized bees, indeed have resulted in a shortage, and we expect that it will impact by altering the types of crops that we may grow or the areas in which we may grow them.

Of immediate concern, of course, are the areas of the Rio Grande Valley with significant pollination of crops in that area, and the population moving into the California agricultural scene, eventually into the Florida agricultural scene where we have the production of crops that serve throughout the States for the majority of the year. It is indeed a significant factor.

Senator AKAKA. APHIS failed to promptly respond to the 1987 Florida infestation of veroa mites in honeybee colonies, only to see the pests spread to 30 States by 1991. What are some of the mistakes that were made in the case of the veroa mite infestation, and

what are the economic consequences of this problem if this problem continues?

Mr. CARON. The problem of the veroa mite is one where there was an attempt made to slow the invasion of this alien species, and as you indicated, it was not successful. The consequence is that we have this shortage of bee colonies to meet our current pollination needs and a great hardship to many individuals within the community who depend upon the products and the services of pollination of the honeybee.

A number of factors that could have perhaps reduced this very rapid spread of the alien introduced veroa mites involved a better coordinated effort of APHIS working with the State agencies to do that, to try to come up with a program of cooperation of working in terms of this particular introduced species. The very same points that I was trying to relate to in Africanized bees, of so many players on the scene that we do need some sort of coordination that will be more effective to try to reduce the spread.

Senator AKAKA. The African honeybee is a public threat as well as a threat to U.S. agriculture. APHIS is responsible for developing a response to the agricultural threat, but does not address the human health issues. Does this arbitrary division of responsibility make sense given the fact that we are talking about a single pest that represents a threat to humans and agriculture?

Mr. CARON. Perhaps in some respects it does not make sense, but is the reality of how agencies must work and deal with something that does represent such a broad spectrum of potential threats, both to agriculture, to our beekeeping industry, maintenance of colonies for pollination services by our growers of those crops requiring pollination, and, of course, then the general public.

We need to have bite-size portions of that particular—instead of an agency trying to deal across the spectrum, have bite-size portions. So, in part, the fragmentation, yes, does make sense and does make it better able for the various agencies to focus.

Senator AKAKA. Mr. Schmitz, some non-indigenous plant species pose problems depending upon how the species is used. Purple loosestrife, for example, is viewed by horticulturists as a desirable plant because of its color and form. But to managers of natural areas, it is highly damaging because it grows prolifically, displaces indigenous plants, and provides lower quality habitat and food for wild animals.

Do we have to take sides when a single species is a weed in some instances and a desirable species in home gardens or other controlled settings? Should we adopt a "better safe than sorry" approach?

Mr. SCHMITZ. Absolutely, and I will tell you the reason why. There are hundreds of plant species that are available to home gardens and for landscape ornamentals. But how many of our wetlands are remaining in our Nation? Many of them have already been lost through development and agriculture, and we want to preserve what is left. And an invader like purple loosestrife or melaleuca in the Everglades is going to steal what remains of our Nation's biological heritage. So I guess you could say I am biased, but I feel very strongly that we have to make some choices. And I do not think this is going to seriously impact gardeners or for

landscape ornamental use because, as I said, there are hundreds of species that are available to them.

One thing I want to make perfectly clear is that not all exotic plants are bad, and I do not want that impression going out that we are looking at—that there is some environmental purity here. Most exotics are not invasive in the natural environment. But the ones that are invasive, they are eating our lunch, especially, in Florida, and we need to do something about it. We need to screen them, screen some of these in the future for their potential invasiveness.

Senator AKAKA. Dr. Singletary, do you have a comment?

Mr. SINGLETARY. Yes, sir, and thank you. You mentioned specifically purple loosestrife. I would like to cite for you the example of what is being done in North Carolina relative to that species. We do not have populations of it to the extent that a lot of our Northern neighbors do, but it is established in North Carolina, and we have undertaken an eradication program because it is of a limited acreage in the State. We have had very good cooperation from the nursery industry and garden clubs and the home-owning public once the facts are laid out. Sure, there is some resistance, but through educational efforts we have been able to move forward with this approach.

These are some of the kinds of things that have to be done with these kinds of species, and what I am saying is it can be done if it is approached in the right fashion, and particularly where you have got limited populations of something, like the example I give you in North Carolina.

Senator AKAKA. Mr. Schmitz, your testimony stressed that the unrestricted spread of alien species would destroy our country's rich biodiversity and that most Americans are unaware of the resultant ecological damage. You just mentioned the possibility of reviewing some of these tropical introductions for possible damages to our environment.

I will also mention that many are unable to equate alien species invasion with a change in their lifestyle, to which you also referred. My question to you is: How can we draw attention of this issue to the citizens of this country?

Mr. SCHMITZ. That is a good question. I think the OTA report has certainly brought it together, at least for a lot of resource managers. This problem is not even well known or has not been well known even by resource managers. We have run into resistance by people who should know. However, the word is getting out.

It is only during the past 10 to 12 years that scientists have identified the problems caused by invasions of alien plant and animal species and how they are changing, and in many cases detrimentally changing the ecosystems.

I think the problem basically is the concept of an ecosystem. I think most of the public is not aware of what an ecosystem is, so they cannot recognize ecosystem damage. I will even give you an example.

I guess it was 9 years ago I was down in Miami, and we were regulating the aquarium plant stores down there. We were trying to prevent the introduction of a new species, like another hydrilla, into Florida's waterways. Now, I have a master's of science degree

in biology and am familiar with the concept of ecosystems. And as I was driving down the road, there was acre upon acre of melaleuca forests on both sides, and I was not aware of the problem until I went to a symposium in 1988 held by an Exotic Pest Plant Council.

Now here I am a biologist, and I was not even aware of the problem or could not identify the problem. But once I heard the scientists talk about the changes that were occurring in these ecosystems and how diversity just crashed as melaleuca invaded these once highly diverse wetland systems, then a light bulb went on in my mind and went, "Uh-oh, there is something out that we are not dealing with."

I came back, and I tried to convince my agency that we needed to take a look at this problem a lot more seriously than we had in the past, and basically there was a lot of resistance because they did not really understand it until I brought the scientists up from south Florida and we had a seminar in Tallahassee.

So I think the problem is a kind of a hard sell, in a way, because if you think about it, environmental issues are divided really into two arenas in this country. One, you have the environmental issues that directly affect humankind—clean air, clean water, exposure to hazardous waste, et cetera. But in wildlife areas, people are less familiar with that because to them they perceive that it has absolutely no importance or has no direct relevancy to their everyday lives.

I guess you can divide it up that people vote and wildlife does not vote, and so we have to be their voices, in a way, or be stewards of what is in their best interest. And most ecosystems, or what remains of them in this country, are remnants of these once formerly large contiguous ecosystems that went from coast to coast. Now essentially what we have is island-like habitats surrounded by a sea of agriculture or urbanization. Like your State of Hawaii, they are showing the same propensity to being invaded by exotics. So Hawaii, even though you are an island State, you are not unique in the sense of what we have left in Florida because we have island-like habitats also.

Senator AKAKA. One possibility is television exposure. People could easily view the program and have a better understanding of the problem.

Mr. SCHMITZ. I have been successful. We have been on "Good Morning, America" and "ABC Evening News," but I still think the environmental community in this country needs to take a stronger stand with it. I will give you an example. They are spending $400 or $500 million to clean up the water coming off agricultural areas south of Lake Okeechobee that is going to flow into the Everglades. If they do not deal with the melaleuca invasion out there, what you are going to end up with is very nice clear water flowing into a melaleuca forest, and not resembling anything like the Everglades.

Exotics in this country, the invasive ones, they are like environmental cancers, and if you do not slow or excise them or manage them, they are eventually going to kill the patient, meaning the ecosystem.

Senator AKAKA. Florida's Exotic Plant Pest Council is developing an extensive prioritized list of harmful alien species. Are there

some initiatives developed by the Florida Exotic Plant Pest Council that you would recommend to Federal pest agencies?

Mr. SCHMITZ. Yes. As a matter of fact, the reason why the Florida Exotic Pest Plant Council has been successful is because it is basically comprised of mid-level managers. We are not dealing with territorialities. Basically people are coming together who understand really what is at stake, and we have been successful.

But, unfortunately, coordination only goes so far in dealing with this problem. Funding is essential, as Howard was saying before. Funding is essential. We do not have the money to go out and effectively manage the exotics that we have right now.

Another problem is we really need someone to take the lead in this issue. I disagree a little bit with Howard, but I really think a Federal agency needs to be appointed to have the responsibility. Because what we are finding in Florida is that since no one has the responsibility, there is still a fragmentated approach.

Let me give you an example. From the turn of the century through the 1960's, water hyacinth control was fragmented. There were various State and Federal agencies that were every now and then dabbling into water hyacinth management. During the 1950's and early 1960's, we had 126,000 acres of water hyacinths that clogged our waterways. It was not until the early 1970's when the State of Florida, the legislature, established a comprehensive aquatic plant control program in the State.

What happened was that since there was now a lead or a designated agency, we coordinated the efforts. And instead, duplication of efforts were eliminated. We funded money for research to find long-term solutions to water hyacinths, and today I am pleased to report that we have now about a thousand acres of water hyacinths in the State of Florida. That is a result of integrated plant management, a combination of herbicides and bio-control agents, and the concept of maintenance control, maintaining an invasive exotic plant species at their lowest population level so that you minimize the amount of pesticides that go out in the environment and you minimize the cost to the taxpayers most of all, from my perspective, you minimize the negative environmental impacts that these exotics cause in the environment.

Senator AKAKA. In your statement you proposed the need of a lead agency. I hope that whatever pests there are, we might be able to designate lead agencies to deal with them, and in some cases on an emergency basis before the problem gets out-of-hand.

Mr. Singletary, dedicated Federal data bases, such as the Animal Welfare Information Center at the National Agricultural Library, have been established to provide State and Federal agency users with ready access to the latest techniques in their discipline or industry. Would an agricultural data base on the biology, control, and eradication techniques of alien plant and animal species be a useful tool?

Mr. SINGLETARY. Most definitely, Senator, and I would like to potentially add to what that data base might contain in terms of looking at plant and animal species worldwide, with emphasis on potential noxious qualities and invasiveness. If we had access to that kind of information plus the elements contained in your question,

I think we would have a much more sound basis for making initial judgments as it relates to this.

However, I would point out that even the best of data bases containing these characteristics, when you are dealing with a species out of its natural environment, it is not always known what the potential invasiveness or deleterious qualities that a species might have are until it moves into a new environment. But certainly a data base with these qualities outlined I think would be a very useful primary means of defense in terms of making the initial judgments.

Senator AKAKA. The Asian tiger mosquito was apparently imported in shipments of used tires. This pest is an aggressive biter and prolific breeder. It is also known as a carrier of dengue fever and two forms of encephalitis, one of which has a 30 percent mortality rate in humans.

In your testimony, you mentioned that human health costs due to the presence of plant pests are staggering. In what other ways do alien pests have damaging effects on human health?

Mr. SINGLETARY. I will try to outline my concept of what some of these potential other human health factors could be. Let's take toxic plants, for example. Giant hogweed, a federally listed noxious weed, has sap that causes irritating reactions to the skin. Poison ivy is an introduced species in this country. Also, there are plants that can kill livestock or cause adverse reactions in livestock.

Let's take invasive plants in water systems, for example. By clogging water systems, you decrease the water quality, water holding capacity in impoundments, and you create breeding grounds for mosquitoes by not having moving water in rivers and streams.

You also have a factor, although it may be more indirect, and that is the displacement of native species whereby some of these plants have medicinal purposes. Then you have the direct impact from impacts of mosquitoes, let's say. We have heard the example of the Africanized bee, the direct impact on public health, stinging. Also, the imported fire ant, allergenic reactions and that kind of thing, similar to what you have from bee-stinging incidents.

And I would like to go back and just cite you one example related to livestock, and that is tropical soda apple in Florida. This is a newly introduced species in Florida. It is a pest in pasture situations, and livestock will not graze on it. What happens is you have less area available for forage for livestock because it just creates dense thickets. There are thorns on the stems and leaves. You could consider that a human health aspect in terms of potentially reducing a supply of food for this country.

But to go on with the example, livestock inadvertently spread this pest because they will feed on the fruit in the fall, and the seeds go through the animal. If that animal is sold in commerce, then that is indeed a means that this pest artificially moves this noxious weed.

So there are some examples and some specifics regarding your question.

Senator AKAKA. Thank you, Mr. Singletary.

Dr. Carlton, you gave some impressive testimony about the dangers of ballast water and the aquatic pests carried in that water.

Of course, such pests have also invaded the bays and lakes of Hawaii.

What implications does ballast water have for island ecosystems such as Hawaii?

Mr. CARLTON. We do not know very much so far about ballast water release in island ecosystems. There have been cases of exotic species introduced into ports and harbors, such as in Hawaii, and we think that a good deal of the marine life, for example, in Pearl Harbor and Kaneohe Bay and Coconut Island area and the Ala Wai Canal and so forth, really are composed of a great many exotic species carried into, for example, the Hawaiian Islands by shipping traffic over the past several decades.

In fact, however, the attention on many islands has been almost entirely on the terrestrial species, the land-dwelling animals and plants, and so we have a really very poor data base on understanding about some of these marine invasions and what they have done on many islands. There is no question, though, that a lot of ballast water is being released in ports and harbors. We have some data on that for Hawaii already, and it is of concern in the same general sense that we are concerned with other locations, and that is that we really cannot predict very well when the next release will result in a major invasion.

Senator AKAKA. Zebra mussels, Dr. Carlton, are an ever-expanding threat to the Midwest. I understand they are beginning to migrate into the Mid-Atlantic region. I am not sure that anyone has seriously considered the impact of these pests in the West. If you consider the number of Federal, municipal, and private dams, aqueducts, and water projects located throughout the West, the thought of a zebra mussel infestation is frightening.

Would you speculate on the risks associated with zebra mussels migrating to the Western lakes, rivers, and water projects? Describe the economic and environmental consequences that such an infestation could have on the region?

Mr. CARLTON. You are certainly right, Senator, in the potential for zebra mussels to gain access to the Western United States. Last November the California Department of Agriculture intercepted a boat that had come out of Michigan, and in the intake of that boat, the engine water intake, were zebra mussels coming across the California border at Needles. In this case, those mussels were dead, but it shows that such a transport event is very likely and is in many ways inevitable. In a sense, then, we really cannot stop this invasion.

What we know about the zebra mussel comes from 150 years' experience in Europe and for the past half decade or more now in North America. The impact on industrial and other water systems in the West will be vast. It is daunting to consider what will happen when the zebra mussel gets to the California water systems, for example.

There is no question that we are looking at hundreds of millions of dollars of retrofitting, of maintenance, of removal of zebra mussels once they hit the West. That is an immediate, obvious impact in terms of an economic industrial threat. Biologically and ecologically, the zebra mussel will also take a tremendous toll. Zebra mussels extract a huge amount of food from the ecosystem, from

the water column. Clearly to support hundreds of millions and billions of zebra mussels requires some energy. That energy is being transferred to zebra mussels, and much of that energy may have gone elsewhere, for example, to native species. Thus, the potential to alter the ecosystem, the trophic web of the ecosystem, it is just absolutely fundamental. We are learning about that potential right now.

In terms of other ecological impacts, we have already seen the disappearance of some native mussels in parts of the Great Lakes. There is a great fear now that a number of our endangered species of native mussels may, in fact, become extinct. The zebra mussel is really the final straw.

I think that there is no question that education activities will be extremely important at slowing the spread of the zebra mussel from the East to the West, and from the North to other parts of the South. Right now, actually yesterday, the fourth international zebra mussel conference just concluded, and over 500 people met in Madison, Wisconsin, to address these issues.

Senator AKAKA. Most introductions of game fish have sought to improve sport fishing, an industry largely dependent on stocking and introductions. Federal and State fish resource agencies often manage resources with fishing in mind, not necessarily for fish or fish habitat. Such releases have rarely had any positive biological impact on receiving habitats and ecosystems. I say this as a sport fisherman concerned about protecting fish communities.

Can we meet the needs of the sport fishing industry at the same time we protect native fish populations?

Mr. CARLTON. Senator, I am not a fisheries biologist, but I can speak to some of the more general principles involved with that kind of a concept.

The sport fishing industry all over the world really is a balance between on the one hand the economic and the biological and the aesthetic benefits of sport fishing and food fisheries and biological control and on the other hand the impacts on the natural ecosystem.

In many ways, the needs of the sport fishing industry have been fairly well served over these past many decades. The movements of large-mouth bass, brown trout, sunfish, rainbow trout, other salmonid fishes, have been extensive across the face of North America, and many of those movements continue.

I think the real critical issue is to make sure that these kinds of activities no longer impact existing populations of native fish, but particularly the native fish that are now restricted and that have been decimated by human activities in terms of decreasing their range and decreasing their population size.

Another critical balance will be that the activities of those who would like to expand or enhance or maintain sport fishing industries do not inadvertently impact some of the remnants of our native fish populations.

Senator AKAKA. In 1990, the EPA convened a workshop on introduced aquatic nuisance species. One result of this workshop was a recommendation that the United States aim for no new introductions of non-indigenous aquatic nuisances.

Do you agree with this recommendation, and do you think a zero tolerance policy is a desirable objective?

Mr. CARLTON. A zero tolerance policy for nuisance species is exactly what we need.

Senator AKAKA. Thank you very much, Mr. Carlton. I thank the entire panel for their testimony. This will be certainly helpful to our Committee, as well as to the country. At this point I would like to move on to the next panel. If time permits, I will ask the members of the Panel 1 to return to the witness table so that I can direct some questions to the entire group.

Thank you again.

Senator AKAKA. For the next panel, we have Dr. Faith Campbell from the Natural Resources Defense Council, and Dr. Deborah Jensen of The Nature Conservancy.

We are glad to have you here. We look forward to your statements. Dr. Campbell?

TESTIMONY OF FAITH THOMPSON CAMPBELL, PH.D.,[1] NATURAL RESOURCES DEFENSE COUNCIL, WASHINGTON, DC.

Ms. CAMPBELL. Thank you. It is my pleasure to be here on behalf of Natural Resources Defense Council to talk about the impacts of invasive alien species. Some of us call it biological pollution.

Biological pollution costs Americans money. There is at least $2 billion lost in timber revenues as a result of invasive alien pests. Gypsy moth-infested areas suffer a 20 percent reduction in recreational use. Cities and towns throughout the country are spending approximately $100 million per year to remove dead and dying elm trees. And nursery owners in the Northwest lost an estimated $1 million in 1950's dollars—so that is probably five times that much in today's money—due to the spread of the root disease on Port-Orford-cedar. Christmas tree sales are restricted in various parts of the country because of exotic pests established on the trees.

The U.S. Department of Agriculture alone is currently spending about $30 million per year to maintain harvest levels of tree species which have not already been virtually eliminated by exotic pest trees. Most of these funds go to one species: suppressing the gypsy moth. NRDC believes that there is inadequate attention to other exotic pests which threaten the extinction of certain tree species or severe ecological disruption.

We hear very much nowadays about ecosystem management, a direction that we applaud. Biological pollution is the greatest threat to forest ecosystems of all. The chestnut was 25 percent of the standing volume of the Eastern deciduous forest in 1900. It is now, for all practical purposes, gone.

What has happened to the wildlife of the Eastern forests that ate the nuts from the chestnut, the butternut, the berries from the dogwood, all of which are now gone from all or large portions of their range, and also nuts from populations of oak and American beech, which are also being reduced by exotic pests?

The Eastern hemlock, I believe you have a hemlock branch up there, with attached the egg cases of the hemlock woolly adelgid.

[1] The prepared statement of Ms. Campbell appears on page 78.

Eradication of the hemlock could harm trout streams throughout the Appalachians and up into New England by raising stream temperatures and siltation loads.

Out West, 80 to 90 percent of the white bark pine trees in Glacier national Park and Bob Marshall Wilderness are infected with white pine blister rust. The large seeds of the whitebark pine are a major food source for grizzly bears and several other species of wildlife of these mountain areas.

It is difficult to know how to address problems as widespread as these. The maps that I have here indicate tree species in seven cases that are heavily impacted—those with the red circles are virtually eliminated—as well as two pests, the gypsy moth and the larger pine shoot beetle.

The most efficient method, widely recognized and already recommended by previous panelists, is to eliminate introduction in the first place. As you have noted, this task belongs primarily to APHIS. Quarantines often delay rather than prevent introduction, but that delay is very valuable because it defers damages, it defers the costs of dealing with those damages, and it allows scientists time to develop more effective controls. But, of course, that third point is valid only if the scientists are working on develcping controls during that time period.

To be more effective, APHIS must first ensure that it does not weaken existing regulations on importation of nursery stock, which is a very major source of introductions of exotic pests of trees that I am dealing with and, of course, of other pests, including some of the plants themselves. APHIS must also adopt stringent regulations governing imports of logs and other unprocessed wood.

In looking at its regulations, which are now out for public comment, I believe APHIS should give greater attention to fungi and other disease pathogens which appear to pose a greater threat than the insects to which APHIS automatically gives its attention. NRDC is also concerned about the prevalence of bark-inhabiting insects on debarked logs, pests transported on dunnage, crates, or pallets, and undeclared raw wood imports in full container loads that are hardly ever opened by inspectors.

The U.S. Forest Service also has an obligation to do more research and mitigation efforts aimed at the forest pests that are already established and especially to go beyond the gypsy moth, although the Forest Service is better on that than APHIS is.

The Forest Service also needs to find a way to become more flexible. The concept of an emergency fund is important there as well because the long budget process does not allow it to respond promptly to newly discovered outbreaks.

Increased funding and personnel are necessary. That is difficult to say at this time, but it is true. So is improved integration with other experts and concerned interests. Several States have very active programs, many academic scientists are experts. A lot could be done with better integration of knowledge.

Alien pests of North American trees have caused significant losses: monetary, ecological, and aesthetic. Through your leadership, I hope that we can develop a comprehensive program which could restore the health of our forests and the other ecosystems

which the other panelists have addressed from the threat of exotic pests.

As I mentioned, these maps illustrate a number of species that have been hard hit already by exotic pests, and I did give you the sample of the hemlock. Please do not go out and grab a hemlock immediately after touching that. Wash your hands first.

Thank you.

Senator AKAKA. Thank you very much, Dr. Campbell.

Dr. Jensen?

TESTIMONY OF DEBORAH B. JENSEN, PH.D.,[1] THE NATURE CONSERVANCY, ARLINGTON, VA

Ms. JENSEN. Good morning. Thank you for the opportunity to be here to testify about the threats posed by non-native species.

I work for The Nature Conservancy which, as you know, Senator, is an international nonprofit conservation organization dedicated to the preservation of biological diversity through the protection of threatened species and their ecosystems.

We own and manage 1,300 preserves nationally. We have a presence in all 50 States. This morning I would like to talk about the problems we struggle with as land managers; problems that are posed by invasive exotic species.

Other panelists have already spoken eloquently about many of the threats posed by invasive plant and animal species. My written testimony contains other examples. What I would like to focus on this morning are some of the challenges of trying to manage and control these indigenous species and point out that it is neither easy nor inexpensive, and then make some recommendations about changes that could be made to help us get ahead of the problem.

As you mentioned in your opening remarks, there is a silent invasion going on of non-indigenous species into natural areas of the country, and it is best thought of, as Dr. Campbell has stated, as biological pollution or environmental contamination.

The consequences can be diverse, wide-reaching, and often severe. And at times, these species change the nature of the ecosystem that they have invaded.

Because these species threaten biodiversity on our preserves, our land managers must control and manage them to protect the resources for which we bought these lands. I would like to tell you about one case study where we are struggling to control invasive non-indigenous plants and give you a sense of how hard it is to succeed at this task and how hard we try.

The case is the Blowing Rocks Preserve in Florida. It is a 73-acre site along a barrier island in southeast Florida. There is about a mile of shoreline there. Now, this preserve is the nesting site for the endangered leatherback turtle, for the threatened loggerhead turtle, and for the green sea turtle. We acquired the site in 1968. At the time, it was already dominated in the dune ecosystem by non-native plants. There was a particular problem posed by the Australian pine, Casuarina equisetifolia. The pine had changed the nature of the dune ecosystem, both the shape of the dunes and

[1] The prepared statement of Ms. Jensen appears on page 87.

their movement patterns. We believe these changes could have harmful consequences for the sea turtle.

We were particularly concerned because the pines shade the dunes and their roots obstruct sea turtles from trying to lay eggs on the dunes.

Because we know that sea turtle eggs are very sensitive to the temperature of sand during incubation, scientists hypothesize that shading the dunes may be changing the temperature of the sand, and as a consequence changing the sex ratio of the sea turtles hatching from the nests. Making the sand cooler creates more male turtles and fewer female turtles. This is not advantageous to species that are already endangered, where we would prefer an equal sex ratio over an increase in males. We need the females to maximize reproduction.

In the mid-1980's, we decided to take an aggressive approach to the restoration of this preserve. Staff and volunteers used chain saws, heavy equipment and herbicides to clear the dunes of exotics. We then planted natives to begin restoration of the ecosystem. As others have mentioned, you cannot simply remove the exotics and expect restoration to occur. You also have to replace the natives to reestablish the ecosystem and its associated functions.

Between 1985 and 1988, we cleared and restored 14 acres. Not a very large area, but it took quite a lot of work. We have continued these activities since 1988, and the cost to date, including the value of the donated labor, exceeds $34,000 per acre.

Now, I mention this because while this case is extreme case, it is not unique. These figures provide some insight into both the financial costs and the human energy required to manage non-native species and restore native species.

I would like to make a few remarks about changes I think we could make to address the problems faced by invasive non-natives. They are similar to many of the comments we have already heard today.

The OTA report has done an excellent job at identifying the problems and suggesting policy remedies. I would like to underscore three recommendations.

Prevention is the most important. We must prevent the release of new harmful invasive species. The current regulatory efforts have focused primarily on preventing the release of plants and animals that pose a threat to agriculture. Insufficient attention is paid to those species which have adverse impacts on natural areas. We would like to see more attention paid to preventing the release of invasive species as a means of protecting biological diversity and natural areas.

Secondly, as many have stated, we must encourage cooperation among the many agencies that are involved in managing these problems, both increasing the ability of these agencies to screen and prevent the introduction of new attacks and coordinating activities to manage and solve the problems where they already exist.

As you are well aware, there is an unusual problem in Hawaii. Particular attention has to be paid to coordination in Hawaii. Progress is being made, in part because of your Alien Species Prevention and Control Act, however, much remains to be done. We need a better rapid response strategy and we need better manage-

ment of problems on the ground as they occur, not simply on the prevention side.

Finally, we need more money for research into technologies to control the existing problems, and more resources to manage Federal lands where there are numerous invasive species problems that are not being adequately addressed. The agencies themselves do not have either the financial or staff resources to tackle the problems they face.

In conclusion, invasive non-indigenous species pose a serious threat to the integrity of biological diversity in the United States. We see that there are three components of a solution: prevention, improved control through cooperation, and more financial and human resources dedicated to research and development of technologies and management approaches to solving problems on public lands.

The Nature Conservancy is committed to working with you, the Congress, and public and private entities to help solve the problems caused by invasive species. We are grateful that the Committee is taking the time to explore these problems and develop policy solutions. Thank you for inviting me, as a representative of The Nature Conservancy, to testify on this topic.

Senator AKAKA. Thank you very much for your testimony.

Dr. Campbell, you paint a bleak picture of the threat to forests, but mention that a comprehensive program could restore many of our tree species. With limited funding, how would you balance prevention on the one hand, with disease eradication and forest restoration on the other? Which deserves greater emphasis?

Ms. CAMPBELL. I am going to straddle that one, Senator. Sorry. Partly, I think I have the luxury to do that because they are two different agencies, and I recognize the funding limitations. Both agencies need to do more. APHIS really needs to focus on the wood imports, and as I also indicated, it needs to do a better job than it has so far on the horticultural imports, which have been a major source of pests.

APHIS does not have adequate staff to do a complete inspection of everything. I think APHIS should explore user fees. Other countries use them. New Zealand uses them. It is time that the importer pay something for the risk that is associated with the benefits that importer is going to enjoy.

As to the existing forest pests, I think that the Forest Service has shifted some money into this area, I am happy to say, and I think that there is a lot that could be done with cooperation. There are a number of states that are quite active in this. There are a number of academic experts. So while I think some more money would be useful, I think in the Forest Service case particularly a better means of exchanging information, setting up networks that focus on the individuals who are knowledgeable about particular pests or particular tree species could go a long way to identifying the most promising techniques and trying to apply them. It is time in some cases to put out some seedlings, for example, into the woods and see if they are going to survive. In other cases, we are not quite to that stage.

But I think that even with the limited funding and agreeing with Dr. Singletary on the importance of weeds as well, there is a lot

that can be done if the agencies would move. And I would just take advantage of this opportunity to say that APHIS is one of the most recalcitrant agencies that I have ever dealt with, and I would encourage you and the other members of this Committee to lean on them as hard as you can. They are not going to deal with the forests or the weeds unless somebody tells them explicitly that they must and keeps on their tail about it.

Senator AKAKA. Thank you, Dr. Campbell.

Dr. Jensen, The Nature Conservancy is well known. In Hawaii, they are very active. The people of Hawaii appreciate the commitment of your organization to habitat species conservation in our State.

In a 1987 survey, the National Park Service asked its park superintendents to identify the problems which most threaten the well-being of our parks. Park superintendents were allowed to rank problems of all kinds: crime, vandalism, shortages of resources, and so forth.

The response of park superintendents was overwhelming. They rated alien pests as the most common threat to park natural resources.

As a private land manager, Dr. Jensen, would you agree with the priority that park superintendents have given this problem?

Ms. JENSEN. Yes, Senator, I would. In fact, one of our staff members, Dr. John Randall, has conducted a similar survey of land managers in our 50 State programs. He asked if invasive plant species were a management problem for them. All of the land managers responding to the survey said that invasive plant species were a serious management problem on their preserves. Sixty percent said they were one of the top 10 management problems they face, and 13 percent said it was the number one management problem on their preserve.

The programs reporting the worst problems were Hawaii, California, and Florida, but it is certainly a very high priority issue for our organization.

Senator AKAKA. The September report of the Office of Technology Assessment has a full chapter devoted to a detailed case study of the threat that alien species pose to native ecosystems in Hawaii. The report described Hawaii as the State most in need of a comprehensive policy to address non-indigenous species, and recommended that Hawaii, because of its geographic isolation, was in need of a separate national policy with its own programs and resources.

The Nature Conservancy has one of the largest programs in Hawaii. Do you agree with this OTA proposal?

Ms. JENSEN. While I agree with the findings of the OTA that Hawaii needs special attention, I would hope we could create a national policy that would work outside of Hawaii as well as in Hawaii. As we have heard today, there are problems in all the States of the country. The problems are due to the lack of a comprehensive national policy which addresses aquatic and marine ecosystems as well as the terrestrial ecosystems.

So I would hope we could make Hawaii the exemplar and use it as a place to learn how to make a national policy work.

Senator AKAKA. At this time I will ask some general questions to be answered by all of you, including those in the first panel. Will the first panel please return. The second panel may remain at the table.

The fundamental question for Congress to consider is whether we need a more stringent and comprehensive national policy on the introduction and management of harmful alien species. The next question is whether current laws can be modified to achieve a comprehensive scheme to prevent the introduction or spread of these noxious weeds and pests.

While the answer to the first question—Do we need a more comprehensive policy?—may seem obvious, the answer to the second question—Do we tinker with the existing laws or start from scratch?—is a more challenge inquiry.

I would like to ask Dr. Campbell to respond to these questions, and others on the panel can State their views following hers. Dr. Campbell?

Ms. CAMPBELL. Thank you, Senator, for giving me the hot potato. I have come to the reluctant conclusion that tinkering with existing laws is probably going to be more effective. I am reluctant about saying that because it is a Nationwide problem that crosses all boundaries of agency jurisdiction, political jurisdiction, type of species jurisdiction. But I think we have had several experiences over the last 2 decades of trying to move the Forest Service to the Interior Department, move the marine species system into—put all living organisms under the same Secretary. None of these has ever gone anywhere. And I am reluctant to wait while we try to restructure the Federal Government.

So I think that we should build on existing statutes. The Federal Noxious Weeds Act, there are detailed proposals for amendment that would go a long way, although not all the way, to answering these problems. In some other areas that I work on, for example, the tree pest problem, I do not think it is a statutory problem. I think it is an agency will problem, and I think that is something that oversight hearings and expressions of interest from here on the Hill can help out with.

There are very definitely some national issues that must be faced by anybody who is trying to deal with this problem, and I would say that the first one is one you have already identified, the lack of awareness. And I would hope that with greater attention to ecosystem management, with the formation of the National biological survey, with the Forest Service doing its own attempt to define ecosystem management, and probably similar things going on in the marine agencies that I am unaware of, now is the time for the Federal agencies to use their access to media publications of their own and to the press generally to educate people about ecosystems and the damages caused to them by various factors, including explicitly exotic species.

The other major issue which we have danced around so far today, really, is the fact that there are economic interests that benefit from these introductions, and they are no doubt poised to fight efforts to control them. And we are going to have to gather our strengths and our arguments and go out and start negotiating with these folks if we hope to make progress.

In those two areas, in educating the public and in negotiating with the beneficiaries of introduced species, I think probably that is better handled—it is easier to make your case if you do that across the board. Since CEQ has been abolished, I am not sure which agency should take the lead on it. It is not obvious anymore. If they still existed, I would say they should do it. I guess that bucks the job to the Office of Environmental Policy at the White House, and I would hope they would pick it up.

Senator AKAKA. Any other views? Mr. Singletary, you mentioned in your testimony that there should be a revision of Federal noxious weeds laws, and that would likely entail tinkering with the present laws.

Mr. SINGLETARY. Yes, sir. I often preach to the people that work with us: Do you know how you make progress? And my classic response in my lecture is: One step at a time. And I look at the issue that we face holistically here today in that there are only a limited amount of resources ultimately that can probably be put to this. And creating a super-agency and that kind of thing and trying to pull all of these things together, number one, I am afraid from a cost perspective that that might be prohibitive. And when you get so deeply engrossed in agency policies and politics about shifting and that kind of thing, there are natural roadblocks that even Congress would face in terms of doing that kind of thing. That is why I favor a more coordinated approach and a tighter control over the coordination function as it relates to that.

Again, I will go back to the OTA report and say that that is an excellent blueprint. It makes a number of—it lays out a number of specific policy options that would accommodate it in the kind of approach that I have espoused to you, sir.

Senator AKAKA. Any other views to express on comprehensive policy or tinkering with the laws?

Mr. SCHMITZ. Yes, I have a comment.

Senator AKAKA. Mr. Schmitz?

Mr. SCHMITZ. I think the States need to take more responsibility. Florida has taken responsibility. We are in the process of evaluating and we are going to make recommendations to our legislature on a comprehensive program to become established that will manage research and control invasive alien plant and animal species in public lands. But the most important thing that we really need is Federal money. The Federal Government played a role in helping to spread a lot of the exotics that presently plague Florida's environment, and it would be nice if at least we could get matching funds freed up or something like that, where the State puts up 50 percent and the Federal Government puts up 50 percent, at least in terms of finding long-term solutions such as bio-control research.

We have a hodgepodge of agencies from Federal, State, and county right now that are funding bio-control research for melaleuca, and if any one of those agencies pulls their funds out, it threatens the entire program. Many times in the course of the last several years we have come close to losing bio-control research. The USDA just wanted to fold up and leave, essentially because they were just tired of trying to get money out of the various Government agencies.

So I think it is important. When I say a lead Government agency, I am not expecting someone who is going to have tremendous authority over everything that is done in this country to manage invasive alien plant and animal species, but someone at least you can go to who can be a depository for information and can tell you what the best management practices are, can give advice to States, and also where States can apply for funding to go out and manage invasive exotics.

I understand, with the many agencies that we have there, that certainly none of them will want to surrender responsibilities from the lands that they manage. But it would be nice if there were at least some central area that we can go to, from the State of Florida perspective, that we could maybe get funding or something from them to go out and manage or conduct long-term research.

Mr. CARLTON. I might just comment for a moment, Senator.

Senator AKAKA. Mr. Carlton?

Mr. CARLTON. I think that we certainly do not—I will agree with the rest of the panel that we do not have to start from scratch, but what we probably need is far more than just tinkering with what we have, starting with a different philosophical foundation. We do have a great amount of regulatory frameworks available, but what they lack is a philosophical foundation, which would make a lot of people seriously care about those regulations.

Senator AKAKA. Dr. Jensen?

Ms. JENSEN. As we have already learned, many resource managers in our Federal agencies are not yet aware of the problem. Some of the education effort has to be directed at state and Federal agencies as well.

While we have the beginning of a framework for a national policy, we do not have a coherent approach. There are a lot of different approaches that need to be taken, and we will not be able to create—I would not support creating—a single entity or a single approach because of the diversity of ecosystems and organisms we are facing. I think that there are many steps that, together, can create a policy that will work for all of us.

Senator AKAKA. Federal laws and regulations have been characterized as "patchwork" and "disjointed". If we return to the chart listing Federal agencies with alien species responsibility, perhaps we can better understand why this is so. It is a very long list, and it is easy to see why coordination—as several of you have mentioned, including Mr. Schmitz—among agencies is difficult, but needed.

In your opinion, should one Federal agency have the lead responsibility for alien species control and eradication, or can this problem be managed through tighter coordination among agencies?

Mr. Schmitz, do you propose a lead agency?

Mr. SCHMITZ. Well, I think my last answer kind of gave an overview that we are not looking for an agency that is going to have total jurisdiction over all the other agencies. What I am looking at is something similar to like the Centers for Disease Control where people can, maybe called Center for Exotic Pest Plant and Animal Control, where people can go for information, where funds and grants will be available to universities to conduct research into what is the best way to manage these species at the lowest cost to

the taxpayer, and produce management techniques that are environmentally palatable.

So if I am saying a lead agency, at least there is someone you can go to and ask for at least information, what is the current rate of spread, maybe conduct surveys, and pull all the information together out of the various Government agencies.

Before the OTA report was published, it was impossible to find out what Federal land management agencies were doing. What I am looking for is something similar to like the Centers for Disease Control for dealing with exotics.

Senator AKAKA. Any other views? Dr. Campbell?

Ms. CAMPBELL. I think it is possible to pull together teams aimed at particular groups of pests. Certainly on terrestrial plants we're dealing with, actually, probably most of those agencies. But there is a clear agency with legal responsibility for the imports; that is APHIS. And then there is an interagency team of the Federal land managers that is developing policy, and I am not sure they have chosen a lead agency. I have some thoughts on which one would make sense. I think the National Park Service, but other people may not agree.

In fresh water aquatic systems, the most logical agency is the Fish and Wildlife Service because although it has, to some extent, limited jurisdiction, it at least has jurisdiction across the country on fresh water. Once you get into the estuaries and bays, then you have a little complexity between them and NMFS, because out in the ocean it is the Commerce Department, National Marine and Fisheries Services. And it is the Coast Guard, of course, for the ballast water.

But I think that for specific kinds of problems—well, I think we can divide this problem up into maybe 10 types of situations and find logical lead agencies for each of those 10. The problem would be, other than what Don Schmitz suggested of an overall information source, which I think would be a good idea, to try to address everything across the board I think would be too time consuming to try to construct, even if we could get everybody to agree on jurisdiction.

Senator AKAKA. Any further views on this? Many citizens are reluctant to accept the reality of an alien species invasion. They see the abundance, the diversity, and aesthetic value of our indigenous species and cannot seem to grasp the threat as being real. Why is this public perception so different from scientific reality? How can we best educate people about the dangers of non-indigenous species? Dr. Carlton?

Mr. CARLTON. When you ask that, my first reaction is that the public perception about virtually every environmental issue is different from scientific reality, so that this is nothing unique in terms of invasions. There is always a major gap between what the public perceives about what is going on in the environment and what scientists believe is going on in that same environment.

Certainly, and directly, it is because many people do not know, do not recognize, and do not understand the history of what is around them. Environmental history is not taught generally in any curriculum, and so what people perceive as natural is usually relative to what they grew up with. An aboriginal State of nature for

almost everyone is their childhood. And a return to that aboriginal State is often couched in terms of, "You should have seen it when I was a child."

That means that if you grew up with certain species around you, you may simply not even know that the environment was remarkably and radically different in the absence of some of these invasions.

Other invasions can come in, and my colleagues on the panel here can comment on them, which are remarkably abundant and people just do not notice because of a lack of awareness of what is going on in the environment around them, again.

Also, there is a confusion between species that are native and species that are so-called naturalized, and a certain number of people might believe that if a species has been in the environment for some length of time, although it originated elsewhere, that it has somehow become an integral part of the community, that it has become naturalized. In fact, a species, if it originates somewhere else, can never be native to that environment, and naturalization is an extremely difficult concept in terms of ecological and biological issues.

How long it takes a species to become completely integrated with a new environment is simply unknown. And to assume that a species that has been present for 100 or 200 years or 300 years has become naturalized when other species have been present for hundreds of thousands or millions of years probably would reveal some ignorance of how species fit into the ecosystems.

Senator AKAKA. Mr. Singletary?

Mr. SINGLETARY. Senator, this is an extreme difficult issue to deal with, and in my experience in dealing with this—I have talked with you briefly about purple loosestrife in response to one of your questions a while ago. When there is a specific target in terms of a pest and a specific community to deal with, you can make progress in terms of educational efforts because there is a targeted audience and that kind of thing.

I will give you another example relative to that. This Asian gypsy moth introduction that we are dealing with, we have had in excess of 50 public meetings in New Hanover and Brunswick counties in North Carolina where this eradication project will be undertaken. And I think we have a high level of public understanding through the media and that kind of thing in that area as it relates to the specific introduction problem and what ultimately may need to be done.

Again, that is a targeted audience, a targeted environment, and that kind of thing. But when you look at this thing holistically and you realize that, let's say, in suburbia where we have—and I do not want to pick on a city, but let's use New York City as an example. People living in an inner-city neighborhood and so forth, how many of those people really have an exposure that they have a real concept of what a natural environment is?

So it is a massive situation to deal with, and I think you can make progress in specific situations where there are specific things that you need to deal with. But attacking this thing holistically, I do not have a good answer. It is a part of basic education, and I

think it is something we will struggle with, with a lot of problems that we face in this Nation today.

Senator AKAKA. Mr. Schmitz?

Mr. SCHMITZ. When I was interviewed by the National media, they asked me—after I gave them a tour of the melaleuca-infested landscape and the Everglades, and they asked me, "Why should we care?" And I gave them the standard biologist's answer about the inherent value and beauty of this ecosystem and its complexity, and their eyes kind of glazed over, and they looked at me and said, "Why should we care?" And I thought for a few minutes, and I said, "Well, it is a real estate issue." And they looked at me and said, "Why is it a real estate issue?" I said, "Well, in many cases that we have bought, purchased these environmentally sensitive lands, not for their mountains." In Florida we do not have any mountains. What we bought our lands for to preserve them for future generations was the biological characteristics of the landscape. And the exotics coming in are displacing—I mean, it is ruining what we bought this land for in the first place. And I said it is devaluing the taxpayer's dollar that was paid on these lands.

So I thought it was kind of a real estate problem, and they liked it.

Senator AKAKA. Dr. Jensen?

Ms. JENSEN. I thank you for that comment. We think it is a real estate problem, too.

I think one of the challenges for the public to understand it is that there are many problems and they are diverse. It is easier to get the public to understand a single species in their area that is causing a problem. It is harder to get the public to understand the impact of the invasive exotic species on the whole ecosystem. It is hard to teach people about a zebra mussel changing the food web in the lakes. It is hard to teach the public about the changes that the pine may cause by changing the temperature of the sand, or the alteration of the water table that may be caused by introduced Tamarix in desert oases. Those problems are not evident to the eye. They need to be measured. It will take public education to teach people to think about ecosystems and to understand that the way ecosystems function is part of the health of the ecosystems we are trying to protect.

Senator AKAKA. Dr. Campbell?

Ms. CAMPBELL. In the case of the forest pests, it should be easier. It just has not really been done. There are photographs of what chestnut forests used to look like. It was not so long ago that we had them. There are, for example, other photographs of gypsy moth damage. There are photographs of other kinds of pests or plants such as the dogwood, which everyone loves, and we can have pictures of live healthy ones and pictures of dead ones.

I think that it is, again, a challenge to everybody—my organization, all environmental organizations, Federal and State agencies that have authority over these issues—to start making the point. None of us has been doing it consistently. It is a relatively new issue. It is getting more media attention. We just have to keep it up and always, every time somebody mentions ecosystem management, put this in, never leave it out.

Senator AKAKA. Dr. Carlton mentioned that no State is immune to the effects of these species. Therefore let me ask you one question. Would a strengthened Lacey Act be a partial improvement on the current system of combatting these pests? Dr. Carlton?

Mr. CARLTON. No question about it. The Lacey Act is one of the tools, but at the moment it is highly selective. I can speak toward marine issues better and aquatic issues better than terrestrial issues. The Lacey Act identifies specifically only a very few species that we actually have direct control over, and so that everything else goes down to the State level. The State level has such a complex array of regulations which have little enforcement in many arenas that that is the point where we lose control. So I would certainly say a strengthened Lacey Act in a number of directions would be the way to go.

Senator AKAKA. The Lacey Act has also been criticized for not providing comprehensive regulation of interstate transport of federally listed species and for not being clear regarding its application to hybrid and feral animals. Programs to control or eradicate alien fish and wildlife are piecemeal and lack emergency measures and have no proactive components to catch problems early. That has been the criticism of the Lacey Act, and thus the reason for my questions on whether or not the Act should be strengthened to improve upon our current system.

Are there further comments on that question? Dr. Campbell?

Ms. CAMPBELL. I think it is analogous to the Federal Noxious Weeds Act that there should definitely be a ban on interstate shipment of anything that does get put on the Federal list, whether it is the Lacey Act list or the Federal Noxious Weeds Act. It makes no sense to ban the import and spend money on trying to control the spread if you are going to continue to allow these plants and animals to be shipped around the country unregulated. That would be the most obvious and the lowest cost step that could be taken in both cases. It will run up against political opposition, but it is definitely needed.

Senator AKAKA. If there are no more questions or responses, let me close with a few observations. First I want to say thank you very much for your testimony. I also want to thank our staffers, Mickey Prosser and Kerry Taylor, for their preparation and work in organizing this hearing.

It is abundantly clear that invasive alien plant and animal species cause great harm to our country, both economically and biologically. We have seen that human migration and population growth, increasing trade and travel, and even global climate can influence a species' movements. The enormous changes to existing native species occurring now, as well as the potential impact on future generations, demand a thoughtful but comprehensive approach at the highest levels of Government.

Both the OTA report and today's testimony describe an uncoordinated patchwork of laws, regulations, policies, and programs. Significant gaps exist for the entry of alien fish, wildlife, weeds, and for vectors of human diseases. Management policies are inconsistent or inadequate and often in conflict with one another.

I believe we have a choice about the kind of world in which we live, and legislation may well be part of that choice. The Congress

and the administration must consider comprehensive actions to halt the flow of invasive and threatening species.

We must encourage interagency coordination and cooperation at the State and Federal levels. Federal agencies should work creatively to solve jurisdictional problems. We should provide the financial resources both for research and for land management agency operations, and we must institute education and enforcement efforts equal to the task. Your testimonies have helped in these respects and will certainly be helpful to the Committee.

Today's testimony has been useful and productive. Next Tuesday, March 15th, I will chair the second hearing on harmful non-indigenous species in the United States. We shall have the opportunity to hear from OTA as well as several of the Federal agencies responsible for the care of our natural resources. I encourage you all to attend.

I thank all of our witnesses again for the excellent testimony, especially your recommendations and observations. We will have some questions for the record, and I will appreciate your cooperation in responding.

The Committee will keep the record open for 30 working days to receive additional written testimony.

If there are no further questions or comments, this concludes today's hearing, and the Committee will stand in recess subject to the call of the Chair.

[Whereupon, at 12:39 p.m., the Committee was adjourned subject to the call of the Chair.]

HARMFUL NON-INDIGENOUS SPECIES IN THE UNITED STATES

TUESDAY, MARCH 15, 1994

U.S. SENATE,
COMMITTEE ON GOVERNMENTAL AFFAIRS,
Washington, DC.

The Committee met, pursuant to notice, at 2:10 p.m. in room SD–342, Dirksen Senate Office Building, Hon. Daniel K. Akaka presiding.

Present: Senators Akaka and Glenn.

OPENING STATEMENT OF SENATOR AKAKA

Senator AKAKA. The Committee on Governmental Affairs hearing on Harmful Non-Indigenous Species will come to order.

Alien pests represent a serious threat to our Nation's agriculture, environment and economy. While they often fail to receive the attention they deserve, 4,500 foreign species inhabit our land, air and waters. A significant number of these species cause serious economic harm. No region of the country can escape the slow, silent invasion of this destructive force.

Today's hearing is the second I have chaired on harmful non-indigenous species. Last Friday, witnesses from the scientific and conservation communities gave their recommendations about how to address this problem. We will now hear from the Federal agencies responsible for research, prevention, control and eradication of alien species. We will also receive testimony from the Office of Technology Assessment, which recently issued a comprehensive report on the subject.

According to the OTA, we have no real national policy to combat harmful alien species. The current system is piecemeal, lacking rigor and comprehensiveness. Federal and State initiatives simply cannot keep pace with new and spreading pests.

Non-indigenous species attack our economy on all fronts. According to APHIS, American farmers suffer crop losses of $2 to $3 billion each year due to non-indigenous weeds. Losses would be far higher if farmers did not spend more than $7 billion annually for pest control.

During the early 1980's, the utility industry spent $4.5 billion to clear water lines and correct other fouling problems caused by Asian clams. American consumers paid the bill for this massive retrofit. An additional $100 million is spent annually to control zebra mussels, hydrilla, and other aquatic pests.

A recent Federal study of the risks associated with Siberian timber imports estimated that losses of $35 to $50 billion could occur

from the introduction of two pests, the Asian gypsy moth and the nun moth.

According to the U.S. Fish and Wildlife Service, non-indigenous species have been a contributing factor, or the major factor in the listing of one-quarter of all threatened and endangered species. A number of species have already become extinct as a result of alien pests. There is no way to place a dollar value on the loss of these resources.

Alien pests don't just compete with native species. They change the rules of the game by which native species live. As a result, we are rapidly losing our living heritage of plants and animals that constitute the foundation of biological diversity.

Both the OTA report and the witnesses at last Friday's hearing described an uncoordinated patchwork of laws, regulations, policies and programs which, in theory, are designed to protect us from damaging infestation. Yet, significant gaps permit the entry of harmful alien fish, wildlife and weeds—as well as vectors of human disease. Management policies are inconsistent or inadequate, and often in conflict with one another.

Hawaii is a perfect example of inconsistent Federal policies. All passengers, cargo and mail bound for the mainland from Hawaii are subject to inspection by APHIS. Only Hawaii faces this requirement. Yet, the Federal Government has been unable or unwilling to protect Hawaii from pests arriving from the mainland and foreign sources. We receive an average of 18 new pests annually—twice as many as any other State—but we cannot get equal treatment from Washington.

When it comes to addressing Hawaii's needs, the Federal Government maintains a double standard. Despite enactment of the Alien Species Protection and Enforcement Act, a bill requiring APHIS and the Postal Service to operate a program to protect Hawaii from arriving pests, no inspection program has been established. A steady stream of pests continue to infest our State, destroying our environment and ruining our crops.

APHIS is not the only agency in charge of alien pest control. I want to return to a chart prepared for last week's hearing which lists the 24 Federal agencies responsible for some aspect of research, prevention, control, or use of alien species. I wanted to invite all of these agencies to testify, but we couldn't find a table long enough.

Twenty-four Federal agencies enforce more than a dozen major laws, and a host of minor ones, governing non-indigenous species. With so many statutes and so many agencies, Federal alien species policy resembles Swiss cheese, and alien pests continue to stream through the holes in policy and enforcement.

The question for Congress and the Clinton administration to consider is how to achieve a comprehensive national policy to guard against harmful alien pests. I hope today's hearing will provide recommendations on how to improve the current system.

So that we have greater time for questions and discussion, I ask the witnesses to limit their testimony to 5 minutes. Your written statements will be printed in the record in their entirety, so there is no need to read from a prepared text. The hearing record will

remain open until April 15, 1994, to receive comments and statements from individuals not present today.

Today, we have our distinguished Chairman of the Governmental Affairs Committee, Senator Glenn, to make some statements in this hearing.

Senator Glenn?

OPENING STATEMENT OF CHAIRMAN GLENN

Chairman GLENN. Thank you, Mr. Chairman. I want to thank my distinguished friend and colleague, Senator Akaka, for holding this important hearing today on the impacts of exotic species on our Nation's environment and economy. It is an important hearing. Sometimes, people joke about these things, but they are no joke for those places that are being infested.

You wouldn't think that Lake Erie, the whole Great Lakes region, Hawaii and Florida would have a whole lot in common besides some beautiful beaches, maybe, but we all share a real vulnerability to the irreparable damage which can be caused by exotic species.

I want to take just a short time to talk about my special concern with aquatic nuisance species and describe the good work done by the Great Lakes Task Force, which helped to secure the passage of the Non-Indigenous Aquatic Species Prevention and Control Act of 1990.

Unique features of our water resources and coastal zones have, over the millennia, fostered intricate and longstanding species associations. Together, these associations comprise the web of life which supports our economy and our culture. In the Great Lakes region, like other coastal regions, the web of life is unique, it is diverse, and it is productive. But exotic species can change all that in a very short time; historically, almost in the blink of an eye.

While aquatic organisms enter the Great Lakes through many avenues, perhaps the greatest threat is by discharge of ballast water from commercial vessels. The impact of this ballast discharge has been especially dramatized by the zebra mussel infestation which now plagues the ecology and industrial infrastructure of our region.

Already, rare native clams have come extinct in zebra mussel-infested portions of the basin. Users of raw water, such as power plants, sewage systems and factories, have spent millions and millions in extra maintenance costs for zebra mussel removal. I have been up along Ohio's shoreline and visited some of those places. I have seen the encrustations, 8, 10 inches thick; in some places a foot thick. It is almost unbelievable what has happened with these growths.

We have real concerns that the zebra mussel or one of the many other non-native species that have been unintentionally introduced in our waters may ultimately destroy our lucrative commercial and sport fishing industry. Folks used to chuckle some when we mentioned the very name of our uninvited guest, the zebra mussel. I still remember when they first brought this subject up to me and said we want to talk to you about zebra mussels. Allegra Cangelosi, who is on our Great Lakes Task Force, and whom some of you know, brought a bottle of these little critters into my office. I

couldn't believe that these things were going to be the huge danger that some people were pointing out they might be. Yet, we went to work on it and went up and talked to the people up by Lake Erie and we were able in 1990 to get the legislation through.

There is nothing pretty about zebra mussels, despite their name, and it is no longer any laughing matter. Nor is the appearance of a fish called the European river ruffe, which is rapidly growing in numbers in the western end of Lake Superior. The cold water waters of Lake Superior are not the optimal habitat for this rather aggressive bottom dweller and the temperature helps slow its spread, but if it gets transplanted into Lake Erie it could well thrive and decimate our native perch supplies there. For those who prize catching perch for a living or just for pleasure, it could have devastating results.

Now, in 1990, we began addressing the hazards which exotic species pose for the economy and natural systems of the U.S. The presence in our waters of the zebra mussel, the river ruffe, and other 100 non-indigenous species attested to a major gap in our Nation's environmental policies, a gap that could seriously compromise all of our other efforts at preserving biodiversity.

It was also apparent that while we as a Nation will invest almost $200 million in fiscal year 1995 to protect our agricultural resources from newly-introduced species of crop pests, and another $100 million to control these pests which are already here, we haven't been doing much to protect our water-dependent industries from similar threats borne by sea.

So we were able to work hard and gain passage of the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990, which established a national program to prevent and control unintentional introductions of foreign aquatic species. In addition, the Act created a ballast management requirement for ships entering the Great Lakes and St. Lawrence Seaway system. These vessels must now exchange ballast at sea or otherwise manage their ballast water to effectively reduce the probability of transfer of foreign organisms.

The law also set up an Interagency Aquatic Nuisance Task Force, led by NOAA, the National Oceanic and Atmospheric Administration and the Fish and Wildlife Service, to develop and implement a national program to prevent and control aquatic nuisance species. Though this multi-agency approach has been difficult to coordinate at times, it really is the only way to achieve any success.

Look at the agencies involved. The Fish and Wildlife Service specializes in the management of inland resources. NOAA addresses near-coastal areas. The Coast Guard enforces shipping requirements to reduce new introductions. The Army Corps of Engineers develops the engineering solutions to zebra mussel removal, and EPA, the Environmental Protection Agency, assesses the environmental impacts of proposed species control measures.

The track record of this task force so far has been encouraging, considering the limitations and funding constraints under which it operates. Although its authorization level is around $12 million per year, it gets about one-sixth of that, $2 million, primarily from the Fish and Wildlife Service. Compared to the $200 million-plus na-

tional price tag for crop pest prevention and abatement, what we get out of the task force is a real bargain.

We as a Nation need to do more to prevent and manage the impacts of destructive aquatic species from foreign lands. Yet, the budgets of key agencies assigned to spearhead this effort really do not reflect a commitment to get the job done. In particular, NOAA has never allocated funds to fulfill its obligation to develop and implement a national aquatic nuisance program even though it is a co-chair of the Interagency Aquatic Nuisance Task Force. Instead, the agency seeks to reprogram the limited funds that Congress has provided for Great Lakes-related provisions of the Act to address its national concerns. This approach is a dead-end street. It will only spread the already inadequate resources so thin that nothing will get done.

So I would urge NOAA and the other agencies involved to get serious about this environmental program and commit new resources to a solid national effort. If there ever was a situation in which an ounce of prevention equals a pound of cure, this is it.

In closing, I want to emphasize the importance of this hearing in raising the awareness of those in other coastal areas to the threat exotic species pose to their industries and their environment. I should point out, when our original legislation was introduced it would have created a ballast management and discharge requirement protecting all of our coasts. But without an infestation comparable to the zebra mussel, there was not much awareness of, or support for, this provision in other regions of the country.

I want the record to be clear that we in the Great Lakes region were not being selfish or insular in the approach we have undertaken. I do hope when we seek reauthorization of this legislation that many of my colleagues on this Committee will seek to include their States in a prevention program similar to what we have now in the Great Lakes.

I would also call attention to another bill I have introduced, the Innovative Ballast Management Act, which would help develop technological solutions to ballast transfers of exotic species. I am honored to have Senator Akaka's support for this initiative.

So, again, I want to thank Senator Akaka for his leadership and interest. It has been a growing problem, one he is addressing across the board. I express our appreciation to our witnesses today, many of whom have helped to get the 1990 Non-indigenous species program off to a fairly positive start. We appreciate your work on that.

Thank you, Mr. Chairman.

PREPARED STATEMENT OF CHAIRMAN GLENN

Good Afternoon. I want to thank my distinguished friend and colleague, Senator Akaka, for holding this important hearing today on the impacts of exotic species on our Nation's environment and economy.

Now you wouldn't think that the Great Lakes region, Hawaii, and Florida would have much in common—besides, of course, our beautiful beaches—but we all share a real vulnerability to the irreparable damage which can be caused by exotic species. I would like to take a few minutes to talk about my special concern with aquatic nuisance species, and describe the good work done by the Great Lakes Task Force, which helped to secure the passage of the Non-indigenous Aquatic Species Prevention and Control Act (PL 101–646) of 1990.

Unique features of our water resources and coastal zones have, over the millennia, fostered intricate and long-standing species associations. Together, these associations comprise the web of life which supports our economy and our culture. In the Great Lakes region, like other coastal regions, the web of life is unique, diverse, and productive. But exotic species can change all this in the blink of an eye.

While aquatic organisms enter the Great Lakes through many avenues, perhaps the greatest threat is by discharge of ballast water from commercial vessels. The impact of this ballast discharge has been especially dramatized by the zebra mussel infestation which now plagues the ecology and industrial infrastructure of our region. Already, rare native clams have become extinct in zebra mussel infested portions of the basin, and users of raw water (such as power plants, sewage systems, and factories) have spent millions in extra maintenance costs for zebra mussel removal. We have real concerns that the zebra mussel, or one of the many other nonnative species that have been unintentionally introduced into our waters, may ultimately destroy our lucrative commercial and sport fishing industry.

Folks used to chuckle when I mentioned the very name of our uninvited guest, the "zebra mussel". Despite its name, there's nothing pretty about it. But now, it's no longer a laughing matter. Nor is the appearance of a fish called the European River Ruffe, which is rapidly growing in numbers in the western end of Lake Superior. Fortunately, the very cold waters of Lake Superior are not the optimal habitat for this rather aggressive bottom dweller and help to slow its spread. But if this fish gets transplanted to Lake Erie, it could well thrive and decimate our beloved native perch themselves. For those who prize catching the perch for a living or just for pleasure, this could have devastating effects.

In 1990, we were finally able to begin addressing the hazards which exotic species pose for the economy and natural systems of the United States. The presence in our waters of the zebra mussel, the River Ruffe, and over 100 other non-indigenous species attested to a major gap in our Nation's environmental policies—a gap that could seriously compromise all our other efforts at preserving biodiversity.

It was also apparent that, while we as a Nation invest over $200 million annually (fiscal year 1995) to protect our agricultural resources from newly-introduced species of crop pests, and another $100 million-plus to control those pests which are already here, we hadn't been doing much to protect our water dependent industries from similar threats borne by sea. So we were able to work hard and gain passage of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, which established a national program to prevent and control unintentional introductions of foreign aquatic species.

In addition, this Act created a ballast management requirement for ships entering the Great Lakes and St. Lawrence Seaway system. These vessels must now exchange ballast at sea, or otherwise manage their ballast water to effectively reduce the probability of transfer of foreign organisms. The law also set up an interagency Aquatic Nuisance Task Force, led by the National Oceanic and Atmospheric Administration (NOAA) and the Fish and Wildlife Service, to develop and implement a national program to prevent and control aquatic nuisance species.

Though this multi-agency approach has been difficult to coordinate at times, it really is the only way to achieve any success. Look at the agencies involved: the Fish and Wildlife Service specializes in the management of inland resources; NOAA addresses near-coastal areas; the Coast Guard enforces shipping requirements to reduce new introductions; the Army Corps of Engineers develops the engineering solutions to zebra mussel removal; and, the Environmental Protection Agency (EPA) assesses the environmental impacts of proposed species control measures.

The track record of this Task Force so far has been encouraging, considering the limitations and funding constraints under which it operates. Although its authorization level is around $12 million per year, it gets about one-sixth of that ($2 million), primarily from the Fish and Wildlife Service. Compared to the $200 million-plus national price tag for crop pest prevention and abatement, what we get out of the Task Force is a real bargain.

We as a Nation need to do more to prevent and manage the impacts of destructive aquatic species from foreign lands. Yet the budgets of key agencies assigned to spearhead this effort really do not reflect a commitment to get the job done. In particular, NOAA has never allocated funds to fulfill its obligation to develop and implement a national aquatic nuisance program, even though it is a Co-Chair of the interagency Acquatic Nuisance Task Force. Instead, the agency seeks to reprogram the limited funds that Congress has provided for Great Lakes-related provisions of the Act to address its national concerns. This approach is a dead-end street; it will only spread already inadequate resources so thin that nothing will get done. So I would urge NOAA and the other agencies involved to get serious about this environ-

mental program and commit new resources to a solid national effort. If ever there was a situation in which an ounce of prevention equals a pound of cure, this is it.

In closing, I would like to emphasize the importance of this hearing in raising the awareness of those in other coastal areas to the threats exotic species pose to their industries and their environment. I should point out that when our original legislation was introduced, it would have created a ballast management and discharge requirement protecting all of our coasts. But without an infestation comparable to the zebra mussel, there was not as much awareness of—or support for—this provision in other regions of the country. So I want the record to be clear that we in the Great Lakes region were not being selfish or insular in the approach we have undertaken.

I do hope that when we seek reauthorization of this legislation, many of my colleagues on this Committee will seek to include their states in a prevention program similar to what we now have in the Great Lakes. I would also call to your attention a bill I have introduced, the Innovative Ballast Management Act (S. 1648), which would help develop technological solutions to ballast transfers of exotic species. I am proud to have the support of Senator Akaka for this initiative.

Again, my thanks to you, Senator Akaka, for your leadership on this issue, and also express my appreciation to our witnesses today, many of whom have helped to get the 1990 Non-indigenous species program off to a fairly positive start.

Senator AKAKA. Thank you very much, Mr. Chairman, and thank you for your statement.

At this time, we would like to begin with our witnesses. On the first panel we have Dr. Windle, and with her is Dr. Chornesky. Both worked on the study produced by the Office of Technology Assessment.

We are happy to have you and we await your testimony.

TESTIMONY OF PHYLLIS N. WINDLE,[1] SENIOR ASSOCIATE, OFFICE OF TECHNOLOGY ASSESSMENT, WASHINGTON, D.C.; ACCOMPANIED BY ELIZABETH CHORNESKY, ANALYST,

Ms. WINDLE. Thank you, Mr. Chairman. We appreciate your efforts in this area and your interest in our particular study.

OTA always hopes for a long shelf life in its reports, perhaps 10 years, even 20 years, and we have every hope that that will be true of our general analysis of this problem. Unfortunately, in one matter we are already out of date. If you can see the maps here, we know that some time between 1992 and last Friday when your witness announced it, African bees spread to Arizona and New Mexico; and some time between 1993 when we had our last data and last week at the International Zebra Mussel Conference in Wisconsin, zebra mussels reached Oklahoma and there are expected to be additional spreads once the full impact of last year's midwestern floods are known.

On Friday, you heard abundant testimony about the economic and environmental harm caused by non-indigenous species, so I will not repeat that, but suffice it to say that I can guarantee that non-indigenous species affect not only Hawaii, but every Member's State that serves on this Committee. We all pay some of those billions of dollars in control costs and other expenses.

You asked us specifically to address the adequacy of current policy. As you noted yourself, it is commonly accepted that the Federal Government has no national policy on harmful non-indigenous species. In some cases, problems are due to missing elements in key legislation, especially the Lacey Act and the Federal Noxious Weed Act. For example, Federal laws leave both obvious and subtle gaps in coverage that States do not adequately fill. This includes some

[1] The prepared statement of Ms. Windle appears on page 95.

categories of harmful non-indigenous species that are not restricted from entry at all.

There seems to us to be a general consensus now that our basic legislation needs changing, although that change would not come without opposition. Such changes could provide, for example, more adequate authority for listing regulated species more quickly, also for providing emergency treatment for early infestations. Often, those are the only hope we have for staying ahead of pests.

But the broadest question is whether we need a stricter national approach. OTA finds that such an approach is justified if Congress' goals include, for example, better protection of national parks and more limited interstate spread of non-indigenous pests. We may never be able to fully predict the risk of new introductions, but we know that both intentional and accidental introductions of fish and wildlife in the past have had about equal chances of turning out badly. That suggests a history of not only poor decisionmaking, but as well the inherent unpredictability of introductions.

For some species, keeping them out is clearly the best strategy. For others, control is easier than interception at ports of entry. So we feel that aiming for a standard of zero entry is both unrealistic and undesirable, especially if stronger exclusion efforts come at the expense of control of those organisms that enter or are already here.

But without better goal-setting, data gathering, and especially evaluations by the Federal agencies, we cannot unquestionably tell whether pre-introduction screening and post-introduction quarantine and enforcement are adequate. We have indirect evidence, however, that our system fails with some regularity. One response to these problems could be stricter screening for invasiveness in federally-funded efforts, especially for plants and fish and wildlife.

Once harmful non-indigenous species enter the U.S., there is no coordinated effort to prevent their spread for large categories of organisms. At least five plants on the Federal Noxious Act list of prohibited importations were legally sold in interstate commerce as of 1990. Compliance with the limited Federal and State laws that limit interstate distribution of noxious weeds is, in effect, largely voluntary.

Amendments to the Lacey Act in 1981 allowed the Fish and Wildlife Service to enforce State-restricted injurious fish and wildlife, but we could find so such interceptions listed among the agency's 1990 accomplishments, suggesting that this enforcement is not a high priority either.

Generally there is insufficient authority and impetus for the Federal agencies to impose emergency quarantines on non-agricultural pests. The Federal role is far larger for excluding, managing and limiting agricultural pests than the corresponding activities for pests of natural areas, for fish and wildlife, and for their diseases.

For example, neither the Agricultural Research Service nor the Soil Conservation Service systematically evaluates plants' invasiveness before they are released for horticulture or for soil conservation. According to one of our experts, at least 7 of the 22 cultivars released by the Soil Conservation Service between 1980 and 1990 could become weeds of natural areas.

Weeds as a group receive little attention from APHIS, and weed control programs throughout the Federal agencies are generally small and underfunded. Recognition of these sorts of problems in natural areas is relatively new and it is one of OTA's major findings. A broader interpretation of current legislation could ensure that weeds of natural areas are better addressed. Also, it seems clear to us that this is one area in which more funding will be needed, especially for weed management on public lands and resource management generally for national parks and other protected areas.

As Mr. Glenn noted, the 1990 Non-Indigenous Aquatic Nuisance Prevention and Control Act is among our most recent efforts to ensure interagency coordination. As such, it provides a case study in the pluses and minuses of interagency efforts. Its successes include the internal discussion it prompted within the Fish and Wildlife Service. The successes also include the intentional introductions policy review and how it aims to improve risk assessments for proposed introductions.

However, the Act did set out a number of assignments that have completion dates that were considerably delayed from those originally set by Congress, and there are two important concerns that remain. The task force chose to interpret the Act as not addressing aquatic non-indigenous species that escape from aquaculture facilities, and States remain concerned that the draft program as the task force developed it lacks mechanisms to disburse funds for emergency control.

We feel that the 1990 law and the task force could have a significant role in preventing unintentional entry and dissemination of harmful aquatic species, but in a number of areas regulations are not underway or planned. OTA concluded that the rocky start of the task force makes its potential in the future uncertain. It is clear to us that Congress' assignment of new responsibilities without funds does not work, and that has affected the task force.

It is also clear that those who are the source of non-indigenous species problems seldom bear their cost. Therefore, OTA suggested that Congress might consider further questions of funding and accountability for harmful introductions. These could include additional entrance or user fees, higher fines for illegal imports, bonding, insurance surcharges, taxes, and a variety of other possibilities.

As you know, harmful non-indigenous species have hit Hawaii and Florida particularly hard. Increasingly, State and Federal agencies, non-governmental organizations, university scientists and agricultural interests see non-indigenous species as a unifying threat, and public education as one important tool to alleviate it. Therefore, OTA is in good company in suggesting that Congress might significantly expand environmental education.

These are Asian clams in this bowl. They were unknown in the United States before they were first detected in California before 1940. By 1986, as you can see on our map, they had spread to 30 States, including 6 of the 14 states that the Committee represents. This bowl-full came from only a few square yards of Potomac River shoreline at Great Falls last autumn, 3,000 miles away from where

they first entered, and we each helped cover those billions of dollars of losses you mentioned in your opening statement.

With harmful species capable of such spread and such cost, many feel that time is running out. Yes, Federal and State agencies have many efforts underway already and, yes, a number are also moving quickly to improve their work, and I am sure that you will hear about these activities today. They are important and it is gratifying that some have been responsive to our work.

But the vision of Jimmy Carter's 1977 executive order haunts us. It could have had far-reaching effects. It could have given us a 15-year head start, but it has yet to be formalized in regulations or fully implemented. Therefore, the Federal agencies need to provide more than reassurance that efforts are underway and that all will be well. Instead, it is crucial that they be specific about what they intend to accomplish, why, and by what date. Anything less jeopardizes national resources and compromises the future of this Nation's rich biological heritage.

Thank you.

Senator AKAKA. Before we begin the questions, let me congratulate Dr. Windle and OTA on their landmark study on non-indigenous species.

Ms. WINDLE. Thank you.

Senator AKAKA. This document is a blueprint for Federal and State response to the alien species threat.

Your testimony covered a wide range of concerns. One, I guess, boils down to Federal agencies really ignoring some of the Acts that have been passed to control these species.

Dr. Windle, New Zealand is a small island Nation with alien species problems as severe as those in Hawaii. Yet, New Zealand is often cited as a country that most effectively addresses alien species. Would you highlight for me and for the Committee the tactics that New Zealand employs to combat this threat?

Ms. WINDLE. New Zealand is particularly interesting because they recently consolidated their laws and regulations that relate to agriculture. I think that was 12 major acts and hundreds of related regulations. Their intent was to be comprehensive, to be forward-looking, to be fair to importers, but also to ensure that they were protecting the country from the possible harm of introductions.

Now, all potentially harmful imports will be regulated through an appointed hazards commission with different groups responsible for advocating introductions and those responsible for cautioning about their potential dangers. They expect that scrutiny for different introductions will vary depending upon the level of risk and eventually any decision about introductions or stopping the introductions will require a careful balance between both the benefits and the potential harms, as defined very widely.

Senator AKAKA. Of the successful policies that have been proven in New Zealand as you know them, what can be used to improve the U.S. response to this problem?

Ms. WINDLE. Some of the methods are things that New Zealand has done in the past. Others are new with this new consolidation of legislation, so we are not sure which of the new ones will ultimately be successful. But it does seem to us that it is clear that their emphasis on agency performance standards and their user

pays approach to inspections, risk assessments and violations would be appropriate here, and both are already starting to be implemented by APHIS.

It seems that a number of the other ways that they approach the problem are possibilities, but are more likely to engender significant disagreement in this country. For example, they have detailed national standards for the introduction of animals, and they also provide for bonding for having funds on hand in case those animals escape and cause harm. In this country, the States are far more responsible for fish and wildlife and such animal introductions than the Federal Government, so that might not be appropriate.

New Zealand also intensively inspects arriving passengers and cargo and baggage and conducts random checks to see how effectively they are detecting things. I know that that is a subject that is often considered here, and there is concern that we would be slowing the arrival of passengers and slowing trade unacceptably if we were to pursue that area as aggressively as New Zealand.

Senator AKAKA. The OTA report contains case studies on alien pest problems in Hawaii and Florida. Both of these States have developed novel responses in an effort to combat exotic pests. In your report on page 223, you State that the efforts of Hawaii and Florida are worthy of attention because they provide lessons for other parts of the United States. Would you please highlight some of these lessons?

Ms. WINDLE. Well, they certainly illustrate that what we lose due to non-indigenous species is often uniqueness. Whether it is the Florida Everglades or whether it is the unusual plant and animal life in Hawaii and nowhere else in the country, we lose things that are unusual, unique and not available elsewhere.

We have also seen in those states that the greatest threats are to natural areas and that any place that is a transportation hub and a tourist destination provides a major route for entry of organisms and a way that they can spread further within the country.

The policy options that OTA suggested in many ways also reflect the lessons that we have learned in those States. That includes the need to coordinate Federal and State approaches, to make those who are responsible for harm more likely to pay for it, and making sure that agricultural and natural areas are better protected. Public education, of course, has been a major effort in Hawaii and Florida, and we see some of the benefits of that that could be applied elsewhere.

Senator AKAKA. APHIS is proposing comprehensive regulations governing the introduction of non-indigenous plant pests. The agency will also propose to consolidate and streamline plant and animal quarantine laws. After these changes are accomplished, what gaps will remain that allow the entry of economically or environmentally harmful non-indigenous species?

Ms. WINDLE. We have seen their proposed consolidation of a couple of years ago, but I haven't seen the most recent proposal, so I can't be very specific. My concern, as we have expressed it in our report, would be that there might be gaps that relate to areas in which APHIS has not been very interested in pursuing efforts in the past. These are the problems in natural areas, places where agricultural pests are also human health pests, and it would behoove

us to keep an eye on some of those areas to ensure that they are included in any such consolidation.

Dr. Chornesky may have something to add about that.

Ms. CHORNESKY. I would just add to Phyllis' list the noxious weed issue, too. Again, I haven't seen their proposed consolidation, so I don't know how effective it would be.

Senator AKAKA. Perhaps the most significant lessons identified in the OTA report are that Federal and State approaches for combatting alien pest problems need to be better coordinated. Based on OTA's investigation, how much coordination takes place today?

Ms. WINDLE. We find that a fair amount of coordination takes place in the agricultural arena, although the States still have complaints about how well the Federal Government listens to them and these relate to when Federal agencies decide to start and stop programs and how responsive APHIS is to local concerns and sees them as potential national problems.

We found it more difficult to determine how much coordination goes on between the Federal and State governments regarding fish and wildlife. We know that the Federal Government provides funds for States to introduce non-indigenous species, usually those that are non-indigenous from one part of the U.S. to another, but we couldn't determine how much cooperation there is to assess the ultimate impact of those species.

We did make a careful analysis of State laws and found that we cannot rely on the States to step in where there are Federal gaps in a uniform fashion. But it would be very instructive to have the States talking to each other along with the Federal agencies to compare some of the very interesting approaches that States have determined that are unlike anything the Federal Government has attempted.

Senator AKAKA. Well, I thank you. Are there any further comments or questions?

[No response.]

Senator AKAKA. If not, I want to thank you again, Dr. Windle and Dr. Chornesky, for appearing here. Your testimony will be helpful, and again I want to commend you for that report.

Ms. WINDLE. Thank you.

Senator AKAKA. I would like to have the next panel move forward: Robert Davison, Department of the Interior, Deputy Assistant Secretary of Fish, Wildlife and Parks; Katharine Kimball, National Oceanic and Atmospheric Administration, Deputy Assistant Secretary for Oceans and Atmosphere; B. Glen Lee, Department of Agriculture, Deputy Administrator, Plant Protection and Quarantine; and William McCleese, Department of Agriculture, Acting Associate Deputy Chief for the National Forest System.

I welcome all of you here today at this hearing. I would like to begin with Dr. Davison and ask for your statement.

TESTIMONY OF ROBERT DAVISON,[1] DEPUTY ASSISTANT SECRETARY FOR FISH, WILDLIFE AND PARKS, U.S. DEPARTMENT OF THE INTERIOR

Mr. DAVISON. Thank you, Mr. Chairman. I want to thank you for holding this hearing today and for your interest in this subject. Also, before I start, I just want to indicate that I have Gary Edwards who is with me, who is the Assistant Director of the Fish and Wildlife Service for Fisheries and the co-chair of the Aquatic Nuisance Species Task Force.

I want to thank you for this opportunity to provide the Committee with a summary of the efforts, policies and concerns of the Department of the Interior concerning non-indigenous species. The global transfer of non-indigenous organisms is one of the most pervasive and perhaps least recognized effects that we humans have on the ecosystems of the world.

It is important to realize that once a species is introduced into an open ecosystem, it is often virtually impossible to remove it. For all intents and purposes, introduction is like extinction; it is forever. Thus, the most important strategy appears to us to be to prevent the introduction and consequent spread of harmful non-indigenous species.

The Department of the Interior manages many programs dealing with non-indigenous species. The National Biological Survey has established a research and monitoring program to determine the ecological effects of non-indigenous species, to develop methods which can be used to prevent their introduction, to develop environmentally safe control measures, and to monitor their distribution and spread. Activities range from evaluating the effectiveness of fences and controlling feral animals in the Hawaii Volcanoes National Park to determining the response of black bears to gypsy moth induced mortality of trees.

The National Biological Survey has recently joined an interagency effort to develop a coordinated approach to contain invasive non-indigenous weeds. In partnership with other Federal and State agencies, the Biological Survey also conducts research on the chemical and biological control of sea lampreys in the Great Lakes.

Additional non-native species research activities being conducted by the National Biological Survey include cooperative efforts by the Alaska and Madison Centers on a study of the role of non-native birds as competitors and vectors of pathogens to native Hawaiian forest birds.

Beyond these activities of the National Biological Survey, the Department is also coordinating with other Federal, State, tribal and local governments to implement the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990. The Aquatic Nuisance Species Task Force established by the Act has proven to be an excellent mechanism for interagency coordination.

As co-chairs of the task force, the Fish and Wildlife Service and NOAA are jointly responsible for implementing most provisions of the Act in consultation and cooperation with other members of the task force. The Fish and Wildlife Service provides staff support to

[1] The prepared statement of Mr. Davison appears on page 100.

the task force and, with the National Biological Survey, chairs a number of task force committees.

The cornerstone of the Act and the major responsibility of the task force is the development of the Aquatic Nuisance Species Program. This program has undergone public review and will be sent to Congress this spring following administration clearance. The primary objectives of the Aquatic Nuisance Species Program are to prevent the introduction and dispersal of aquatic nuisance species; to monitor, control and study aquatic nuisance species; and to disseminate related information.

The Fish and Wildlife Service and the National Park Service, in cooperation with State and local governments, have developed a zebra mussel response program to prevent the spread of the zebra mussel into the St. Croix National Scenic River. The St. Croix River, a tributary of the Mississippi River, supports several native species of endangered mussels. The Fish and Wildlife Service and the Bureau of Reclamation are working together to determine the feasibility of stopping or slowing the spread of zebra mussels west of the Continental Divide, where they may impact large reservoirs, dams and irrigation systems.

Monitoring of non-indigenous species is necessary to detect new introductions, track their dispersal, and document their effects on aquatic ecosystems. The Aquatic Nuisance Species Task Force has established a detection and monitoring committee to coordinate monitoring activities and develop an information system to collect and distribute this information. This committee, chaired by the National Biological Survey, has proposed to use a geographic information system developed by the Survey for documenting the occurrence and distribution of non-indigenous aquatic species and their rate of spread.

The control element of the Aquatic Nuisance Species Program outlines a risk assessment and management process to ensure prompt and systematic evaluation of proposed control measures. In response to a control proposal submitted by the Great Lakes Fishery Commission, the task force developed a control program to slow or stop the spread of the ruffe from Lake Superior. In addition to serving as chair of the task force's Ruffe Control Committee, the Fish and Wildlife Service is conducting population studies, surveillance programs, and information and education programs.

Research is an important element of the Aquatic Nuisance Species Program. The Act directed the task force to develop a research protocol to ensure that, "research activities carried out under the Act do not result in the introduction of aquatic nuisance species to waters of the United States."

The Research Protocol Committee, chaired by the National Biological Survey, developed a protocol that consists of a risk assessment and a set of guidelines outlining preventative containment and confinement procedures that must be followed if research is conducted under the Act.

The National Biological Survey has conducted considerable research to support management of problems related to aquatic nuisance species. Largely in response to the zebra mussel invasion, about three-quarters of the National Biological Survey's fiscal year 1994 budget on all non-indigenous species, $3.5 million, is directed

at aquatic species, especially the zebra mussel. The National Biological Survey is currently preparing a 5-year plan for Congress on prevention, containment and control of non-indigenous aquatic nuisance species.

Finally, I want to say a few things about our efforts to implement other key portions of the Non-Indigenous Act. Section 1102 of the Act requires the completion of three studies on the introduction of aquatic nuisance species. One of these studies, the biological study, is intended to determine whether aquatic nuisance species threaten the ecological characteristics and economic uses of U.S. waters, other than the Great Lakes.

The task force will address this study on a case study basis, examining specific geographic areas where aquatic nuisance species have historically been or may potentially be a problem. In fiscal year 1993, the Fish and Wildlife Service initiated the first two such case studies to examine the ecological and economic effects of biological invasions in the San Francisco Bay and the State of Florida. The case study in Florida is being conducted by the National Biological Survey's Gainesville Center. A case study of the Chesapeake Bay area will also be funded by the Fish and Wildlife Service and is anticipated to begin later this year.

Section 1209 of the Act required the task force to develop and undertake a program to control the brown tree snake. The task force established a Brown Tree Snake Control Committee comprised of representatives of appropriate Federal, State and territorial agencies. A brown tree snake control program is under development.

The National Biological Survey's Patuxent Center is currently conducting research on brown tree snake populations on the Pacific Islands, evaluating the design and feasibility of snake barriers and traps, creation of snake-free areas, methods of detection, and biological and chemical control methods.

The task force has also undertaken an effort to identify and evaluate approaches for reducing the risk of adverse consequences associated with intentional introductions of aquatic organisms. A report to Congress on the findings, conclusions and recommendations of that review has undergone extensive public scrutiny and will be submitted to Congress this spring following administration clearance.

The Department of the Interior is committed to carrying out its responsibilities under the Non-Indigenous Aquatic Nuisance Prevention and Control Act and other authorities to ensure that we protect our fish and wildlife resources from all non-indigenous nuisance species and that we prevent the introduction of new harmful species.

The Aquatic Nuisance Species Program, we believe, could serve as a model for developing a comprehensive national strategy to address the introduction of all harmful non-indigenous species. The completion of the Intentional Introductions Policy Review and the Aquatic Nuisance Species Program, as well as the progress on the research protocol, brown tree snake control and the studies required by the Act, demonstrate the effectiveness of the task force as a forum for cooperation and reflects a shared commitment and

dedication among Federal agencies in addressing non-indigenous species problems.

Thank you. That concludes my remarks.

Senator AKAKA. Thank you very much.

May we hear now from Katharine Kimball?

TESTIMONY OF KATHARINE W. KIMBALL,[1] DEPUTY ASSISTANT SECRETARY FOR OCEANS AND ATMOSPHERE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Ms. KIMBALL. Thank you, Mr. Chairman. I am Kate Kimball, Deputy Assistant Secretary at NOAA within the Department of Commerce. I am also co-chair of the Interagency Aquatic Nuisance Species Task Force which was established under the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990. I appreciate this opportunity to discuss the risks presented by both unintentional and intentional introductions of non-indigenous species. Recognizing that the Committee has heard from other witnesses touching on fresh water introduction, I will emphasize salt water aspects of this issue in my testimony.

The Act was designed to mitigate the overall problem of aquatic nuisance species by establishing an interagency task force to develop Federal policies that would prevent and mitigate the problems associated with introductions of non-indigenous species. Although the majority of funds originally authorized under the Act have not been appropriated, the task force has made an effort to fulfill its responsibilities under the Act.

There are examples of species introductions into marine environments that have had negative impacts, although none as great as the impact of the introduction of zebra mussels. The introduced green algae was first considered to be a nuisance in the area of Long Island in the early 1970s. The species has now spread as far south as South Carolina, and there is concern that if it spreads farther it could affect coral reefs by blocking the sunlight on which they are dependent.

Whenever they occur, there are a number of potential risks associated with both unintentional and intentional introductions. An introduced species may cause the decline of native species in a number of different ways. Indigenous species may be affected by direct predation, competition for key habitat or other resources, or hybridization. Serious pathogens or parasites also may accompany a species when it is introduced.

For example, although of uncertain origin, one only need consider the impact of MSX and dermocystidium on oyster production in the Chesapeake Bay to see the potential problem. MSX and dermocystidium have reduced oyster harvests in the Chesapeake Bay from 3 million bushels a year to less than 100,000 bushels per year.

Pathogens also have a serious impact on a number of economically important species. They have been transferred with salmon and shrimp. The State of Hawaii, for example, has among the most stringent screening requirements for diseases in large part because

[1] The prepared statement of Ms. Kimball appears on page 103.

the introduced shrimp virus, IHHNV, was responsible for major agricultural losses.

The problem of zebra mussel infestation, as has been referred to, galvanized demand for Federal legislation. A number of Federal agencies have provided funding for research on methods to control zebra mussels. To prevent further ballast water introductions into the Great Lakes, the Act mandated that the Coast Guard issue regulations on management of ballast water in the region. Those regulations became effective on May 10, 1993.

As part of the National Ballast Water Control Program, the task force is mandated to conduct ballast water exchange, biological, and shipping studies. Through joint cooperation, the task force has initiated the ballast exchange study, which will assess the environmental effects of ballast water and identify areas, if any, where such exchange does not pose a threat. This project was initiated through a grant from EPA's Office of Research and Development and will be conducted by and administered through NOAA's Great Lakes Environmental Research Laboratory. Additional funds from NOAA and the Fish and Wildlife Service will allow completion of the study by June 1995.

Dr. Davison has already referred to the biological and shipping studies and I won't repeat that testimony here. In addition, I want to discuss briefly the Aquatic Nuisance Species Program which was required under the Act. The program will be sent to Congress after administration clearance and is trying to build on the efforts of Federal agencies, States, tribes, local governments and non-governmental activities so we have a comprehensive approach to this problem.

We also have the task force's Risk Assessment and Management Committee developing a pathway identification risk assessment process to prevent unintentional introductions of non-indigenous species. The committee is currently modifying a process developed by the Department of Agriculture's Animal and Plant Health Inspection Service for evaluating non-indigenous plant pests to develop the risk assessment portion of this element.

A species-specific control process is outlined in the program. The task force has already implemented this process in the case of the unintentional introduction of the ruffe, which has been mentioned previously. In addition, the National Marine Fisheries Service monitors the presence of pathogens in imported seafood through a memorandum of understanding with the Food and Drug Administration. NMFS has also provided technical advice to the State of Hawaii and serves on the Hawaii State panel that reviews proposed introductions of aquatic species. NMFS is also fulfilling an integral role in coordinating the Congressionally mandated intentional introduction review which is currently being reviewed by the task force.

In addition, NOAA's National Sea Grant College Program administers aquatic nuisance species research grants. The Sea Grant zebra mussel program is concentrating on the effects of zebra mussels on infrastructure and the environment and on the development and evaluation of potential control methods. The Great Lakes Environmental Research Laboratory has set up a non-indigenous species coordinated research program. Under this program, research-

ers have set up a monitoring program in Saginaw Bay and Lake Huron. The National Sea Grant College Program also provides education and technical assistance to its Sea Grant offices and marine advisory service program.

The waters of the United States are a resource of immeasurable environmental, economic and aesthetic value. Although the task force did start slowly, we believe we have picked up the pace and by working closely together we are well on the way to establishing a comprehensive program to deal with the risks presented by non-indigenous species. Further recommendations are likely to emerge as a result of some of the studies that have been mentioned. Although it is not possible to prevent all species introductions—indeed, there have been some beneficial introductions—we should be able to reduce the risks posed by non-indigenous aquatic species.

Mr. Chairman, thank you for the opportunity to testify and I will be happy to answer any questions you may have.

Senator AKAKA. Thank you very much.

Now, we will hear from B. Glen Lee.

TESTIMONY OF B. GLEN LEE,[1] DEPUTY ADMINISTRATOR, PLANT PROTECTION AND QUARANTINE, U.S. DEPARTMENT OF AGRICULTURE

Mr. LEE. Thank you, Mr. Chairman. I am very pleased to be here today to discuss the OTA report that is the subject of discussion on harmful non-indigenous species in the U.S. The efforts of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service to prevent and control the spread of non-indigenous species were reviewed in detail within that report.

With me today are several of my colleagues to assist me with questions, should that need arise: Dr. George Winegar, who is the Assistant Deputy Administrator of our veterinary services staff; Mr. Don Hawthorne, the Associate Deputy Administrator of the Animal Damage Control Programs; Mr. Bill Wallace, who is the Director of our Policy and Program Development staff, and also a member of the Aquatic Nuisance Species Task Force.

USDA appreciates the tremendous effort that went into the OTA report, creating such a comprehensive document for our consideration and discussion, and believes that the report generated valuable insight into approaches for handling such difficult issues.

As the report indicates, the negative effects of certain non-indigenous species have created economic losses into the billions of dollars, and you cited some of those in your introductory comments. The OTA report concludes that a dynamic national agenda is needed to effectively address non-indigenous species in the U.S., and we in the Department agree with that conclusion.

APHIS, in particular, has significant experience and expertise in monitoring and evaluating dangers of non-indigenous species and in developing cooperative programs for the exclusion, the control and eradication of certain non-indigenous plant and animal diseases and pests.

We have traditionally in the Department been charged with protecting agriculture in the U.S. from plant and animal pests and

[1] The prepared statement of Mr. Lee appears on page 107.

diseases and noxious weeds. Generally, we concentrate our efforts on excluding the exotic agricultural diseases and pests and, where feasible and cost-effective, we do institute control or eradication programs such as those involving the screw worm, Mediterranean fruit flies, other exotic fruit flies and the boll weevil. On occasions where the disease and pest become established, APHIS may implement programs to manage and prevent their further spread.

The OTA report identified a number of modified or new services that APHIS or another agency could provide for effective protection against harmful non-indigenous species. For example, any proposed introduction, importation, interstate movement, release into the environment, and so forth, of a non-indigenous organism should be examined more closely. The agency is currently developing comprehensive regulations governing the introduction of non-indigenous organisms that may be plant pests. The regulations would provide a means for screening proposed introductions of non-indigenous organisms to determine the potential plant pest risks and evaluation of environmental effects of authorizing the introduction of the non-indigenous organism. That is required under NEPA.

Another area that has been highlighted as a problem is noxious weeds, and there were testimonies last week at this hearing on that subject. The report accurately states that APHIS currently regulates only the interstate transportation of noxious weeds if a quarantine is in place and imposes the quarantine only if an eradication or control program is in place. Now, this practice is in accordance with the legislative history of the Federal Noxious Weed Act of 1974.

APHIS has drafted new legislation that would consolidate and streamline the plant quarantine laws that we currently follow. This draft legislation would expand the agency's role in regulating noxious weeds and would eliminate the requirement that the agency initiate a control and eradication program and impose a quarantine prior to regulating the interstate movement of the noxious weeds. APHIS has also developed a comprehensive weed policy that will form the basis for broader management and control of weeds.

APHIS is a member of the Aquatic Nuisance Species Task Force which is, in part, developing risk assessment and risk management processes to evaluate environmental pests, as well as pests causing more traditional economic damage. Other members of the panel already have addressed that issue.

In addressing the problems associated with non-indigenous species in Hawaii, OTA suggests that a greater Federal role might be warranted. OTA also recognized, however, that increased Federal involvement in domestic arrival inspections in Hawaii would require a change in APHIS' mandate, as well as increased staffing and other resources to the agency to carry out that mandate. APHIS is currently working on implementing a program for inspection of first-class mail from the mainland into Hawaii, which was authorized by the Alien Species Prevention and Enforcement Act of 1992.

The OTA also noted that APHIS does not consistently prevent repeated importation of pest species that are already established in the U.S. "New, different strains of some species potentially may be imported that would worsen the effects and spread into areas

where the pest is not yet well established," quoting specifically from the OTA report.

We do not currently attempt to prevent introduction of all pest species that are already established here, for a number of reasons. Our exclusion policies and decisions must comply with existing international trade agreements, and also must be in accord with science-based risk information.

OTA acknowledges that complete exclusion of pests from the U.S by our agency probably is infeasible. However, the report also asserts that the overall success of APHIS' efforts to exclude pests is difficult to evaluate, in part, because the agency lacks adequate performance measures. That problem is being addressed specifically and hopefully is to be corrected through one of the pilot projects of the Government Performance and Results Act of 1993. The goal of the project is to enable APHIS to better articulate desired AQI program outcomes and to measure whether those desired outcomes are, in fact, being achieved.

We are also responding to the identified need for improvement in the U.S. system of monitoring agricultural diseases and pests through the National Animal Health Monitoring System and the Cooperative Agricultural Pest Survey Program which we have in place.

The OTA notes that biological control agents that are not microbes are exempt from FIFRA and fall under APHIS' jurisdiction. APHIS has not yet promulgated regulations specifically for such agents and instead imposes a permitting requirement developed for plant pests under the existing authority. APHIS is reviewing biological control organisms that are non-indigenous on the basis of their potential for plant pest risk. We intend to have permitting requirements commensurate with the level of risk presented by the organism of interest.

The OTA report points out several perceived weaknesses in the APHIS risk assessment and analysis process. APHIS has sought and continues to work to modify these procedures. With respect to APHIS' requirement for demonstrated risks before preventing imports, APHIS, as a matter of principle, does not require regulations unless a justification can be demonstrated.

Although we applaud and value the OTA study, there are several items that we believe should be brought to the Committee's attention. The study did not cover organisms such as those causing animal diseases, especially those including transmissible diseases from animals to humans. In response, APHIS would like to make clear that control and exclusion of these organisms have constituted major technical, scientific and regulatory successes of this century. APHIS' Veterinary Services Program that produced these successes could offer working models, expertise, suggestions and hard-earned lessons on quarantine, inspection and testing procedures.

We also are concerned about comparing genetically-engineered organisms with non-indigenous species. The act of genetic modification with modern molecular techniques does not by itself render an organism non-indigenous.

When developing and implementing programs to protect agriculture and our natural resources, funding and resources, personnel, and so forth, are usually big questions relative to that. Public

education programs certainly could be used to raise awareness of the economic loss and the environmental harm that can result if prohibited plants, injurious animals, pests and diseases enter our country.

The Department has been and will continue to be closely involved with activities to protect against harmful non-indigenous species. With the U.S. Forest Service, APHIS has worked together to resolve issues related to the importation of unmanufactured wood products, and continues to work together in the control of the Asian gypsy moth which is a recent introduction into the U.S.

As noted earlier, APHIS is a member of the Aquatic Nuisance Species Task Force, and we will continue to work with the Department of the Interior and the Department of Commerce, the co-chairs of that task force. Other members of the task force are EPA, Coast Guard, Department of State, Army Corps of Engineers. Our Animal Damage Control Unit of APHIS cooperates with the Department of Defense and with the government of Guam and the Department of the Interior to control the brown tree snake in Guam.

These are but a few examples, and the Department is very willing to cooperate with the various agencies in developing a comprehensive strategy to impede the movement and invasion of harmful non-indigenous species into our country.

Mr. Chairman, we appreciate the opportunity to appear before the Committee and are open to questions that you might have.

Senator AKAKA. Thank you very much, Mr. Lee.

Now, we will hear from William McCleese, Department of Agriculture.

TESTIMONY OF WILLIAM L. McCLEESE,[1] ACTING ASSOCIATE DEPUTY CHIEF, FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Mr. MCCLEESE. Thank you, Mr. Chairman. We are very pleased to be here to offer our views on this most important subject. I am accompanied here today by Dr. Jerry Sesco, the Forest Service Deputy Chief for Research.

Non-indigenous plant and animal species are a very serious threat to the integrity of our forests and rangeland ecosystems. Chestnut blight, white pine blister rust, Dutch elm disease and leafy spurge are the more commonly known introduced pests in the United States. They are examples of exotic pests that completely changed our forest and rangeland ecosystems by eliminating significant species such as the American Chestnut, the Eastern White Pine and American Elm over much of their range.

Not only did they change our forests, but they resulted in serious economic losses as well. The costs of trying to control these pests, the cost of research, the loss of forest products and wildlife habitat, and the damage to local economies have been in the billions of dollars.

There have been over 200 forest insect pests, 20 major diseases, and over 100 exotic plant species introduced into this country over the past two centuries. The rate of introduction is increasing be-

[1] The prepared statement of Mr. McCleese appears on page 109.

cause of increasing tourism and commerce among Nations. To counter this continuing increase in the rate of introduction, we must expand our application of our regulatory authorities and develop a greater capacity to respond to new introductions. We must also develop improved methods for controlling these exotic pests that have become established and threaten our native ecosystems.

In addition to economic losses, these exotic pests severely affect the forest ecosystem. Wildlife that is dependent upon a declining native species for food or habitat is adversely affected. Species composition and structure of the forests change because species that are immune to the exotic pest replace the susceptible species. In some areas, the Forest Service has identified this changing of species composition and the invasion of exotic plants as the greatest threat to our forest and rangeland ecosystems, including our wilderness areas.

Our rangelands are being severely impacted, also. It is estimated that exotic plants have infested over 14 million acres of Western rangelands, Federal lands. Some of the most invasive species include several species of thistles and knapweeds, leafy spurge, dalmatian toadflax and St. Johnswort. Without their natural checks and balances, these exotic species can freely invade healthy ecosystems, regardless of disturbance, and, once established, create monocultures that severely reduce species diversity and become impossible to control with current methods. The results are severely degraded ecosystems that no longer provide quality wildlife habitat, forage for both wild and domestic animals, or quality recreational experiences.

Some threatened and endangered plant species are at considerable risk, since they cannot compete with these exotic species. In Hawaii, exotic plants such as gorse, banana poka, fireweed and strawberry guava are invading and severely damaging native forest and rangelands. They are also preventing the reclamation of those ecosystems that have been damaged by hurricanes and past management practices.

The Forest Service has always been an active participant in cooperative programs to prevent and control non-indigenous plants and animals. We are working with scientists from other countries to identify plants, fungi, insects and other organisms that could be pests and to reduce the risk of their entry into the United States.

Our coordination efforts with other Federal agencies include working with APHIS to develop a list of exotic pests and potential entry points into the United States. We are also cooperating with APHIS by providing assessments on the risks of importing logs and other unmanufactured wood products from Russia, Chile and New Zealand.

In 1993, the Forest Service participated in organizing and facilitating the Department of Agriculture's Noxious Weed Coordination Group. The group's role is to improve coordination between the Department's agencies with weed responsibilities. The Forest Service is also a member of the team which developed the proposal to establish an interdepartmental team to coordinate Federal agency efforts for noxious weed control. Later this year, a memorandum of understanding will be signed by the agencies within the Departments of Agriculture, Interior, Defense and Transportation estab-

lishing the Federal Interdepartmental Committee on Management of Noxious and Exotic Weeds. The Forest Service will serve as co-chair of this committee.

The Forest Service has been effective in implementing both prevention and control programs for noxious weeds on national forest system lands. We emphasize preventing the introduction of a noxious weed as the most important action. The most effective prevention programs are cooperative efforts with State and county weed organizations, and surveys for invading noxious weeds conducted cooperatively by the Forest Service and livestock permitees.

In wilderness and back-country areas, we are working with outfitters, guides, volunteers and recreationists. In addition, noxious weed information for the public is provided at ranger district offices and recreation trailheads. A new prevention program developed for the national forests in Colorado and Wyoming will require all hay brought on to national forest system lands to be certified as weed-free.

If prevention efforts fail, operations to control the noxious weed must be conducted. The most effective control operations are cooperative efforts between Federal, State, county and private land owners. The control programs are usually designed to eradicate a noxious weed within an entire watershed so that we can prevent a reestablishment by water or animals after the control operation.

To encourage these cooperative efforts, the Forest Service has helped to establish the Western Weed Coordinating Committee which focuses on coordinating noxious weed programs among all land owners. Other coordination actions include the sharing of equipment and personnel, combined training and biological and chemical controls.

When a new exotic pest is discovered in the United States, a series of immediate research activities must be conducted. These include research on how to survey and determine the extent of the infestation, how to prevent the spread of the pest, how to eradicate it, and what, if any, damage it will do. Because introductions of exotic pests cannot be anticipated, it is difficult for us to build funding for this research into our regular program. We are working to solve this problem because we believe that this research is some of the most cost-effective research we can do.

In response to the exotic plant problem in Hawaii, the Forest Service is working with the Park Service, the Fish and Wildlife Service, the Hawaii State Department of Agriculture, the State forester and the University of Hawaii in a biological control program. We are working to develop biological controls and we have been successful in securing release of insects that have been very effective against gorse.

A similar problem exists on national forest system lands. Many species of exotic plants are invading these lands. The Department of Agriculture's Agricultural Research Service is conducting much of the research that is being done on these exotic plants, but there is still much research that needs to be done. To initiate efforts on these forest and rangeland ecosystem noxious weeds, the Forest Service is currently evaluating a proposal to co-locate a biological control unit at Bozeman, Montana, with ARS and with Montana State University.

Exotic pests are a major threat to our native forest and rangeland ecosystems, but the Forest Service, along with other agencies in the Department of Agriculture, will continue to work toward developing more effective and coordinated responses to prevent the introduction of these pests and to control them if they do get established.

Thank you, Mr. Chairman.

Senator AKAKA. Thank you very much, Mr. McCleese.

Mr. Davison, one of the criticisms of the Lacey Act is that regulation and enforcement hinge on a short and non-comprehensive list of injurious wildlife. Adding species to this list, whether administratively or by statute, is time-consuming. The Lacey Act has also been criticized for not providing comprehensive regulation of interstate transport of federally-listed species and for not being clear regarding its application to hybrid and feral animals.

Programs to control or eradicate alien fish and wildlife are piecemeal, lacking emergency measures, and have no proactive components to catch problems early. Options for correcting these problems range from lengthening the list of injurious wildlife, speeding the process of adding species to the Lacey Act list, and authorizing emergency measures to deal with new introductions.

My question to you is would a strengthened Lacey Act, based on some of the modifications I have just suggested, be a partial improvement on the current system of combatting these pests?

Dr. DAVISON. I think the answer to that is possibly yes, and I think the Department would certainly support an effort to look at some of those questions and to ensure that the consequences of some of those changes would help improve our abilities to control undesirable non-indigenous species.

I think, in particular, one of the things that may merit further examination is to look at some kind of ability for pre-listing of species under the Lacey Act on a temporary basis to allow the service to put a species on the list, on a so-called 'dirty list', if you will, while it examines potential risks, and so forth. That may be something that warrants consideration, and we would support such an effort to look at that.

Senator AKAKA. Should the Fish and Wildlife Service assist in the enforcement of State injurious wildlife lists?

Dr. DAVISON. The Lacey Act was primarily intended to assist States in taking enforcement actions against individuals who violated the laws of that State and then no longer were within the jurisdiction of that State. In situations where someone has violated the wildlife law of the State and is still within the jurisdiction of that State, our normal course would be to say that that is an action that is more appropriate for the State to take. But, certainly, in those situations, in which States ask us to help them enforce their injurious wildlife laws or laws that prohibit import to a State of certain wildlife, we would be amenable to providing assistance.

Senator AKAKA. In a December 1993 letter to one of my constituents, the Deputy Director of the Fish and Wildlife Service, Mr. Richard Smith, stated that the Service supports a stringent inspec-

tion requirement for wildlife and plants entering Hawaii. I will place a copy of the letter in the hearing record.[1]

Senator AKAKA. Would you explain in detail why you support an inspection program to protect wildlife and plants in Hawaii?

Dr. DAVISON. Hawaii has a very rich flora and fauna which is found only in Hawaii, in large part because it is an island. Those native endemic species are very vulnerable to introduction of non-indigenous species and a strong inspection program is, I think, an effective way, as New Zealand has found, to prevent those introductions.

Senator AKAKA. Have you, Mr. Davison, raised the issue of instituting a program to protect Hawaiian plants and wildlife directly with APHIS?

Dr. DAVISON. Yes, we have had those discussions. That is in large part, Mr. Chairman, due to the legislation that you passed in 1992.

Senator AKAKA. Mr. Smith's letter goes on to state that the Fish and Wildlife Service supports providing more general authority to USDA to inspect for any biological entity, not just agricultural pests. Please describe on the additional authority that is needed to inspect for any biological substance.

Dr. DAVISON. Certainly our interest here is in strengthening inspection. One option there would be to extend APHIS' authority to inspect not only for agricultural pests but for any biological entity, but I would defer to APHIS for their views about that. There may be other options as well to strengthen inspection.

Senator AKAKA. Hawaii is very serious about the potential threat of brown tree snakes mentioned here today. These pests have decimated Guam's bird population. Twenty years ago, Guam's forests were filled with sounds of native birds, but today there is only silence. Six brown tree snakes have arrived in Hawaii on military and commercial aircraft. If the brown tree snake became established in Hawaii, it would mean the demise of Hawaii's endangered forest birds.

Will the Department of the Interior develop an emergency response plan to be implemented in the event that a brown tree snake infestation is discovered in Hawaii?

Dr. DAVISON. The answer to that is yes. We have currently a brown tree snake network. We would work very closely with the Department of Agriculture's animal damage control program, the Department of Defense, and others. In addition, as I mentioned in my testimony, the Aquatic Nuisance Species Task Force has a committee now on brown tree snake that has developed a program for brown tree snake control if that becomes necessary. That program is nearly complete and ready to be put into place.

Senator AKAKA. In your testimony, the Non-Indigenous Aquatic Nuisance Prevention and Control Act is discussed at great length. You State that this program could serve as a model for developing a comprehensive national strategy to address the introduction of all harmful non-indigenous species.

Have you discussed this proposal with other Federal agencies? Do any of the other Federal witnesses consider the Non-Indigenous

[1] See page 192.

Aquatic Nuisance Prevention and Control Act to be a good model for interagency cooperation on a broad scale?

Dr. DAVISON. We have had some discussions. I probably ought to let them speak for themselves, but I don't think it is the only model. I do think we are all learning valuable lessons about how we might extend such a program. Currently, the task force serves to coordinate actions by agencies, but the actions are actually taken and funded through individual agencies. Certainly, one option that I know the task force has considered is whether the actions couldn't be taken more by a group of agencies and funded that way, but I will let them speak for themselves.

Senator AKAKA. I ask the other Federal witnesses to consider the Non-Indigenous Aquatic Nuisance Prevention and Control Act as a good model for interagency cooperation on a broad scale. Do other witnesses have any comments to make on that? I know some of you have mentioned your support for the Act and are using it now.

Ms. KIMBALL. Mr. Chairman, we would strongly support using the Aquatic Nuisance Species Task Force as a model. We think it enhances cooperation and provides for more effective use of the public money.

Senator AKAKA. Mr. Lee?

Mr. LEE. Thank you, Mr. Chairman. May I defer to my colleague, Mr. Wallace, who serves on that committee, with a response?

Senator AKAKA. Mr. Wallace?

Mr. WALLACE. Mr. Chairman, I would agree with the comments by Mr. Davison and Ms. Kimball that it is a good model. I would also agree with Senator Glenn's assessment that we are off to a fairly positive start in the coordination of Federal activities in these areas.

Senator AKAKA. Thank you for your statement.

Mr. McCleese?

Mr. MCCLEESE. The Forest Service hasn't had a great deal of involvement yet, but anything we can do to increase Federal coordination, we are in favor of that.

Senator AKAKA. Mr. Davison, how is the Fish and Wildlife Service engaged in preventing the interstate spread of harmful non-indigenous species?

Dr. DAVISON. It is primarily again through the Lacey Act, subject to the limitations that we have already discussed.

Senator AKAKA. Are steps underway to ensure a more consistent policy on harmful non-indigenous species within the agencies, bureaus and services of the Department?

Dr. DAVISON. Yes, they are. Certainly one thing that has had that effect has been the 1990 Non-Indigenous Act. Another has been the 1992 law, but there is also an effort within the Department generally for more consistent management, more emphasis on native species management. So I think that effort is well underway.

Senator AKAKA. Ms. Kimball, at Friday's hearing reference was made to a recent discovery of zebra mussels in the ballast of a merchant ship docked in San Francisco. Fortunately, all the mussels were dead. What prevention strategies are now in place to avert the introduction of zebra mussels into the interconnected water systems of the West?

Ms. KIMBALL. I think as Dr. Davison testified earlier, the Fish and Wildlife Service and the Bureau of Reclamation are looking to control the spread of zebra mussels to the West. In addition, the New York Sea Grant Zebra Mussel Clearinghouse and the task force's monitoring committee collects information and tries to provide early warning and detection so that we can prevent the spread of zebra mussels.

Senator AKAKA. Perhaps the greatest unforeseen consequence of the great flood of 1993 is the spread of zebra mussels. According to the March 4th issue of *Science*, the flood washed great numbers of these destructive mollusks down river to the confluence of the Illinois and Mississippi Rivers. Until now, zebra mussel infestations have been confined to the Great Lakes. I will place a copy of this article in the hearing record.[1]

Senator AKAKA. Now that these aquatic pests will soon invade the Mississippi River, which Federal agency will be responsible for slowing their spread?

Ms. KIMBALL. I think what we found with the flood is that while zebra mussels had spread down the Mississippi, the flood is spreading them into smaller and smaller tributaries. As far as Federal response is concerned, the Army Corps of Engineers has the lead in trying to identify and control zebra mussels in public facilities.

Senator AKAKA. Ballast water exchange is never "complete". It is impossible to release all water from a ship before refilling ballast tanks. Thus, vessels from foreign salt water ports bound for the U.S. will continue to discharge some of their original water, as well as any alien plants and animals contained therein.

The recently completed "shipping study", mandated under Public Law 101–646, demonstrated alternative ballast water management technologies which could limit the spread of aquatic alien species. How does NOAA plan to implement, in conjunction with the U.S. Coast Guard, these new ballast water management technologies?

Ms. KIMBALL. I should clarify, Mr. Chairman, that the shipping study was prepared for the Department of Transportation which is still reviewing the shipping study, so it has not been publicly released. But in furtherance of the concern about ballast water management, NOAA and other agencies are considering funding a Natural Research Council proposed study on ballast water management evaluation which can look at these technologies and assess their effectiveness.

Senator AKAKA. Containment of non-indigenous fish and large aquatic invertebrates is difficult. Once released, they spread easily within river systems, and their larval, sub-adult and adult forms may each be disruptive. Attempts at eradication are often a waste of time and money, and often produce only temporary gains.

Do efforts to control aquatic pests such as the zebra mussel in the Great Lakes have any realistic hope of success?

Ms. KIMBALL. I believe they do, Mr. Chairman. I think the key question is keeping the presence of the species below a certain threshold level. Zebra mussels have been introduced for some time. The question is do they become established successfully, and if we

[1] See pages 194–195.

can stay below the critical mass of those species I think we do have a good chance of success.

Senator AKAKA. Mr. Lee, in a November letter to Dr. Sidicki of the California Department of Agriculture, you State that the present program of inspection of Hawaii mail bound for the mainland has substantially reduced the number of pests contained in parcels being mailed. I will place a copy of the letter in the hearing record.[1]

Senator AKAKA. Do you see any reason why a program carried out in Hawaii to inspect arriving mainland mail would not have similar benefits for Hawaii?

Mr. LEE. Mr. Chairman, the inspection process would be equally as effective on mail into Hawaii as on mail out of Hawaii. There is a different set of legal questions to be resolved, however, but the inspection process, per se, would be equally as effective either way.

Senator AKAKA. In my opening statement, I pointed out the inconsistency of Federal policies. Passengers, cargo and mail bound for the mainland from Hawaii is subject to inspection by APHIS. Yet, the Federal Government has failed to institute an inspection program to protect Hawaii from mainland and foreign pests. We view this is a double standard.

Despite enactment of the Alien Species Protection and Enforcement Act, a bill requiring APHIS and the Postal Service to operate a program to protect Hawaii from arriving pests, no inspection program has yet been established. Is there any realistic hope that an inspection program will be instituted in the near future?

Mr. LEE. Mr. Chairman, I believe that there is a realistic hope of instituting a program. Perhaps you are aware that we have been meeting regularly with the State Department of Ag, with the post office personnel and the Fish and Wildlife Service on trying to resolve, or more specifically identify the question of authorities, and also to resolve the legal issue relative to securing Federal warrants for species that are covered under the State law but not covered under Federal law. If those specific issues might be resolved, then I think there is a very good chance of implementing an inspection program.

Senator AKAKA. Mr. Lee, in your testimony you State that APHIS believes it must supplement its current regulations to better meet the problems posed by invading non-indigenous organisms. In response, APHIS is developing comprehensive regulations governing the introduction of alien pests. Will these regulations govern intentional and accidental introductions or reintroduction of alien species to States where they are not currently present?

Mr. LEE. Mr. Chairman, as currently drafted, it deals with the introduction of new species, non-indigenous species. It does not at the moment deal with the unintentional introduction, just the intentional because of permitting and review requirements. However, it further, though, in the draft language does include the interstate movement after a species has been brought into a certain part of the U.S and then subsequent movement from that initial introduction. So it is a yes and a slight yes in response to your question, yes to the part on the intentional part, and then a slight yes to the

[1] See page 112.

question about subsequent movement. It has no provisions, as drafted, for unintentional movement.

Senator AKAKA. What new legislation would be required in order for APHIS to respond to new infestations of plants, animals and pathogens that are not currently subject to quarantine status?

Mr. LEE. Mr. Chairman, I am not prepared to answer that question today. I would be happy to submit for the record a response. It requires review by the OGC.

Senator AKAKA. Please do that.

Senator AKAKA. Would APHIS oppose legislation that permits your agency to cooperatively enforce State laws designed to exclude harmful non-indigenous species?

Mr. LEE. The USDA would be very willing to work with the Committee and review any proposal that would affect the Department.

Senator AKAKA. In your testimony, Mr. Lee, you State that exclusion decisions must comply with existing international trade agreements, and must be in accord with science-based risk information. It strikes me that by the time adequate risk information is developed and determinations can be made about compliance with international trade agreements, alien species may have already become established.

Would you support emergency authority to prevent entry of potentially threatening species until you can complete your risk and trade analysis?

Mr. LEE. I believe the Secretary would use any authority provided him to the fullest value while analyses are being prepared to make those determinations.

Senator AKAKA. As the experience in Guam indicates, the brown tree snake has had a devastating effect, as I mentioned, on birds, including chickens. Yet, APHIS has not classified this nuisance as an agricultural pest. What new legislation would APHIS require to respond to pests that are not strictly speaking agricultural pests?

Mr. LEE. Our current authorities take into account the economic impact of both animal and plant pests on commercial agricultural commodities. APHIS' role to control non-agricultural pests would entail an expansion of the duties required of the agency. However, I would like to point out as I did in my testimony that APHIS is currently developing comprehensive regulations governing the introduction of non-indigenous organisms and both the intentional and then subsequent movement of those non-indigenous organisms. We are very willing to work with the Congress to develop necessary legislation to respond to pests that are not now covered by our authority.

Senator AKAKA. The Hawaii inspection program has been of concern to us. What are the impediments that prevent APHIS from instituting the Hawaii inspection program, and how do we overcome these problems?

Mr. LEE. There are three major impediments, Mr. Chairman, as we see them. One is the question of authorities. One is the legal question. The third is a resource question. I think working with the Committee, we can resolve the third of the three. Working with the agencies, I believe, can resolve the other two. I think those impediments can be resolved.

Senator AKAKA. Mr. McCleese, in a 1987 survey the National Park Service asked its park superintendents to identify the problems which most threaten the well-being of our parks. Park superintendents were allowed to rank problems of all kinds—crime, vandalism, shortages of resources, and so forth. The response of the park superintendents was overwhelming. They rated alien pests as the most common threat to park natural resources.

As a land manager responsible for Federal forest lands, would you agree with the priority that the park superintendents have given this problem?

Mr. MCCLEESE. Well, we have many high priorities, but I would certainly rank these pests as among the highest, yes. It is a serious problem. On the national forests, we have over 6 million acres that are infested with noxious weeds, so just that alone is a major issue.

Senator AKAKA. Funding for the biological control program in Hawaii has continued to plummet, from $426,000 in 1990 to $150,000 today. According to a September 1993 Forest Service report, this amount is completely inadequate for operating an effective biological control research program in our State. Does this mean that the State of Hawaii will be inadequately protected from the continued onslaught of alien pests?

Mr. MCCLEESE. Maybe I could refer that answer to Dr. Sesco from the Research Branch.

Mr. SESCO. Mr. Akaka, we have currently, I believe, about $250,000 invested in our biological control program in Hawaii. However, to adequately address the biological control of weeds, it would take about a minimum of $1 million in our program in Hawaii. I think we are currently addressing maybe three of the weed pests and I think the estimates are around 20 pests in Hawaii. So our program is certainly not well funded in view of the needs.

Senator AKAKA. Yes, and our feeling is that because of inadequate funding, we will be inadequately protected. Are you investigating other means to continue work on this problem?

Mr. SESCO. Well, as Mr. McCleese said, it is certainly a high priority for us. We will continue to give it priority, but there are limited resources that we now have to deal with. One of the things that we need to do is perhaps develop more partnerships with the Park Service, the Fish and Wildlife Service, the State agencies and the universities.

Senator AKAKA. I now propose questions for all witnesses to answer. I believe that education may be the most cost-effective tool to slow the introduction and spread of harmful species. Federal agencies involved with non-indigenous species responsibility could develop broadly based environmental education programs to increase public awareness of problems caused by damaging or unpredictable alien pests. Airlines, port authorities and importers could intensify their public education efforts regarding harmful NIS.

The question is, given the hundreds of millions of dollars that APHIS and other Federal agencies spend on quarantine, control and eradication, do you believe that such an education program would have cost-effective results?

Mr. LEE. Mr. Chairman, APHIS does believe that to be a fact. Because of our involvement in your State relative to the regulatory movement of materials to the mainland, we conducted an in-depth

assessment of the knowledge of our citizens there. After conducting an intense educational program, the knowledge level improved considerably. Along with that, the number of packages moving through the mails intercepted was reduced considerably. So I view that as a very positive approach.

Senator AKAKA. Ms. Kimball?

Ms. KIMBALL. Mr. Chairman, I would agree. Education has been a central part of all the work that we have done. It is important in Sea Grant. The Aquatic Nuisance Species Program itself and the ruffe control program contain elements of education, which we think is very effective if properly done and funded.

Senator AKAKA. Mr. Davison?

Dr. DAVISON. I would just add to that that I agree that education is a cost-effective means of prevention. It is also, in addition to what Ms. Kimball said, a part of the intentional introductions policy review being done by the task force.

Senator AKAKA. Mr. McCleese?

Mr. MCCLEESE. Mr. Chairman, we certainly agree with the need for education. These pests know no political boundaries, so it is very important that everyone understand what the threat is and everyone be aware of what can and should be done about them.

Senator AKAKA. One of the problems that we have with that kind of education is to convince, for instance, the pet enthusiast that the exotic bird or fish would constitute a serious environmental threat if released from captivity. How would you convince them? Ms. Kimball?

Ms. KIMBALL. One suggestion that has been made is to distribute literature at the point of sale so that when people purchase these kinds of animals they will know the impacts of uncontrolled releases.

Dr. DAVISON. Gary Edwards has a specific example that he wanted to share with you.

Mr. EDWARDS. Mr. Chairman, one example of that is in the aquarium trade. People purchase pet goldfish, and when they get ready to move they want to know what to do with that goldfish. One of the easy answers is to take it out and dump it into your local stream, which is not good. We have even published a little brochure [1] and distributed them to aquarium stores to show that if you take that goldfish, and put it in the freezer of your ice box, it quietly goes to sleep. Those are the kinds of things we can distribute to the public to show them how best to dispose of these types of unwanted pets.

Senator AKAKA. Thank you very much, Mr. Edwards. I have often wondered what one should do about aquatic species. [Laughter.]

Senator AKAKA. How would you compare the cost to control and eradicate alien species with the cost of preventing their introduction in the first place? Is it more cost-effective to prevent harmful introduction through education and enforcement than it is to eradicate these pests, or live with the economic harm they inflict?

Ms. KIMBALL. Without question, prevention is far more cost-effective than control after the fact.

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[1] See pages 196–197.

Mr. LEE. Mr. Chairman, I wouldn't say the USDA's view is exactly the same, but it is much more cost-effective to prevent than to control or eradicate or to live with it.

Dr. DAVISON. We share that view.

Senator AKAKA. Mr. Davison agrees.

Dr. DAVISON. Right.

Senator AKAKA. Let me ask Mr. Lee to respond and then the other witnesses can comment as well. APHIS is proposing comprehensive regulations governing the introduction of non-indigenous plant pests. The agency will also propose to consolidate and streamline plant and animal quarantine law.

Mr. Lee, after these changes are accomplished, what gaps will remain that allow the entry of economically or environmentally harmful non-indigenous species?

Mr. LEE. The consolidation of our present authorities will give, we believe, greater authority, expanded authority. It will correct some of the inadequacies that were pointed out by the first panel this afternoon, especially in the area of noxious weeds. We have recognized the deficiencies over the years with those authorities. The consolidated statute thus would broaden the authority, but I should tell the Committee that it still will be related to pests and diseases of agricultural commodities. So there would be a gap between what we currently do now with plant pests, animal diseases and plant diseases and what is desired by the Congress on non-agricultural pests and diseases.

The correction, we believe, will be advantageous because it has a spillover or bleed-over effect into non-agricultural settings, so it does have value that way, but the intent is the agriculture-related activities.

Senator AKAKA. Are there further comments?

[No response.]

Senator AKAKA. I would like to ask everyone to respond to this question again. After the changes that APHIS has identified are accomplished, what gaps will remain that allow the entry of economically or environmentally harmful non-indigenous species?

Dr. DAVISON. Well, Mr. Chairman, there are certainly the gaps that we have discussed previously this afternoon about the Lacey Act.

Senator AKAKA. Well, let me continue. In its September report the OTA concluded that the total number of harmful alien species and their cumulative impacts are creating a growing economic and environmental burden for our country. I ask you to look back over the experience of the agencies in dealing with alien pests. The explosive growth in commerce, tourism, and travel seems to continue with no end in sight.

Do you agree with OTA's conclusion that alien species are a growing economic and environmental burden for our Nation?

Dr. DAVISON. Yes, I agree that the ecological effects and economic effects are becoming increasingly severe.

Senator AKAKA. Ms. Kimball?

Ms. KIMBALL. I would agree with that and add that it is also a problem internationally and we are trying to deal with that now.

Senator AKAKA. Mr. Lee?

Mr. LEE. Yes, sir very much so. We believe, over the information that has been provided, that it would be nothing other than a very burdensome load for us to continue to carry.

Senator AKAKA. Mr. McCleese?

Mr. MCCLEESE. Yes, we certainly agree to that.

Senator AKAKA. You have been wonderful with your responses. If there are no more questions, let me bring the hearing to a close. Today's hearing confirms the need for a more comprehensive national policy to guard against the introduction of harmful alien pests. Invasive alien plants and animals cause great economic and ecological harm to our country, as you have all agreed. The enormous change to native ecosystems, as well as potential future impacts, demands a thoughtful, comprehensive approach from the highest levels of government.

Current Federal and State legislation is piecemeal, at best. Despite the efforts of numerous Federal and State agencies, invasive non-indigenous species continue to enter and spread, causing economic and environmental harm.

We need to embark on a strategic plan, one that will unify the efforts of Federal and State agencies, non-governmental organizations, agricultural interests and universities to combat these threats on a common front. The Federal witnesses testifying today have spoken of their efforts to improve cooperation and to coordinate alien species initiatives. The steps they have taken are meaningful. Given the magnitude of this problem, however, a giant leap forward will be necessary if we are to achieve meaningful progress against the endless tide of new pests.

Congress and the administration must promote stronger interagency coordination and cooperation at the State and Federal level. From your statements, there are indications that you are doing just that. Federal agencies should work creatively to solve jurisdictional problems. Adequate funds should be provided for research, and to fund the agencies that safeguard our natural resources. And we must institute education programs that will enlighten the public about our collective responsibility to prevent the introduction and spread of alien species. New laws will be needed, priorities must be rearranged, and the public must be educated about the dangers of new infestations.

I thank all the witnesses for their testimony and recommendations. We will have some questions for the record and I will appreciate your cooperation in responding.

Senator AKAKA. The Committee will keep the record open for 30 days to receive additional written testimony. I also have some material to be included in the record.[1]

Senator AKAKA. If there are no further questions or comments, this concludes the hearing, and I conclude it with much appreciation to all of you for your help to this Committee.

The Committee stands in recess, subject to the call of the Chair.

[Whereupon, at 4:05 p.m., the Committee was adjourned.]

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[1] See pages 198–201.

APPENDIX

PREPARED STATEMENT OF DR. DEWEY M. CARON

It is with great pleasure that I offer these views on the Africanized bee, an introduced non-indigenous alien insect species now occupying three U.S. States. I began studying this bee in 1982 as it invaded Panama and am continuing my studies to the present time. As president of the Eastern Branch, Entomological Society of America and Board Chairman of the Eastern Apicultural Society, as well as an active research/extension/teaching professor in the field of Entomology and Apiculture, I am fully prepared to assist in your consideration of this important legislation.

The population of this alien honey bee commonly called African or Africanized by my colleagues, or as killer bee by some of the general public and media, represents a contradiction and a challenge for those of us that conduct research and seek to extend scientific knowledge to the public, press and to our distinguished elected officials at local, State and national levels. This bee, whatever we may call it, is a contradiction in its biology and behavior, aspects many eminent scientists have investigated the past 20+ years. It is also a contradiction for the media, for the general public and a contradiction to you and your colleagues in elected and non-elected governmental positions that must develop policies to deal with it. Let me provide some background and then express my views, as scientist and extension entomologist, about how public policy might interface with Africanized honey bees.

Some background on Africanized bees

I will refer to this honey bee as Africanized. It is not native to the U.S. but then no species of honey bee is. The Africanized bee is a population that is highly variable. The population originated from queens carried from Eastern Africa, where it is recognized as a distinct geographical race with certain behavioral and morphological characteristics, to southern Brazil. The intent of this importation into Brazil was to improve the honey bees of the tropical area of that South American country. Brazil, like the U.S., had earlier imported honey bees from temperate climates. This worked fine in the U.S. with a pronounced seasonal temperature and day length cycle but tropical areas have a different seasonality, primarily based on wet and dry weather patterns.

This race of bees from Africa was known for defensiveness and its migratory tendency. It stings rapidly when disturbed and continues nest defense for a longer time and distance at the homesite and it migrates or absconds when climate or food resources become less favorable. Both features are not desirable for beekeeping or management by beekeepers accustomed to the European bee races previously imported into the Americas.

The objective of the importation was to incorporate genetic material into the population of bees in Brazil and to breed a bee more suited to the tropics. Before this was accomplished, the bee accidentally escaped as bee swarms. Biology would tell us that the genetic material of this import should have been hybridized out of existence as only a few bee colonies were being released into a much larger population of honey bees not having the same gene pool. One of the contradictions of this bee is that this didn't occur.

Instead, the honey bee population of southern Brazil was changed over to a gene pattern very similar to the bees carried to Brazil from Africa. Additionally, in contradiction to what was expected, the population began to spread and with more breeding it continued to convert more and more bees of temperate genetic characteristics to what it was—it was after all a bee that through centuries of evolution was well suited to the tropical season. The European race bees it was breeding with had had only a couple of hundred years of adjustment to the American tropics.

This population first drew the attention of U.S. scientists in the late 60s. It was not investigated by U.S. scientists until a 1972 NSF sponsored tour of Brazil by a

dozen of my colleagues. The bee population reached the isthmus of Panama in 1982 where I first began my studies and the U.S. border near Brownsville in South Texas in 1990. The population now occupies all of the Americas except southern Argentina, Chile and the altiplanno of the Andes. In the U.S. it occurs in three States. It has expanded its range slowly northward along the Gulf of Mexico but more rapidly westward to New Mexico and Arizona.

The ultimate distribution of this population within the U.S. is a subject of considerable debate. Based on my studies I believe it will eventually inhabit and predominate, at least in feral or non-managed colonies, in a distribution pattern resembling a "smile"—upward along both coasts (California or higher on the west and Delmarva with adjacent Piedmont or higher on the East Coast) and then across the Southern States from Coast to Coast. Other colleagues believe it will spread more completely within the U.S. and mix more readily with the managed bee hives of beekeepers. Another of the contradictions of this bee, as you can see, is we don't know how extensively the bee will spread in the U.S. This leads to challenges in what should or can be done about this alien invader.

Introduction of Africanized bee genetic material into the U.S. does not fit the same pattern as invasions of other non-indigenous pest species such as Asian gypsy moth, khapra beetle, Mediterranean fruit flies and a whole host of fruit and ornamental plant pests we currently seek to keep out. The Africanized bee is a population of honey bees which moved naturally from Brazil into the southern U.S. The bee is an ecotype that has proved to be better suited for the climatic conditions of the Americas than other honey bees earlier imported for beekeeping.

It is clear in my opinion, that Africanized bees will continue to spread and eventually inhabit a wider range of the U.S. because it will outcompete in the natural selection "game", asserting its genetic makeup over other honey bee ecotypes. We can do little to slow its natural spread, nor eliminate the population as we have done with some pests like screwworm flies, but we must continue efforts to minimize man-assisted spread of this bee much like the program we currently conduct for fire ant control.

What has been done to prevent introduction into the U.S.

As the Africanized bee population spread in South America, we in the U.S. became more aware of its undesirable characteristic of defensiveness. People and animals were stung and some who were allergic, or too old, or too infirmed, or who made poor decisions (such as to attempt to hide not flee) died from receiving too many stings. One instance of a human death has already occurred in the U.S. Many of these stinging "accidents" get reported in the press, not entirely inappropriate for a general public who are entomophobic—scared of insects and relatives like spiders.

In the late 70's, scientists such as Orley Taylor and a number of his graduate students of the University of Kansas and scientists of the USDA, ARS began studies on this bee and its reproductive and defensive behaviors. We began to investigate what makes a tropical bee different from a temperate bee. Studies have continued as the bee expanded northward and have increased in number as the distance has shortened between the population and our own border. The potential negative impact has helped make more funding available for research and extension projects. We know a lot about the Africanized bee but the contradictions of still not being able to better predict what impact it will have on U.S. agriculture, including beekeeping, or the general public, still remains.

Little was done to prevent the population of Africanized bees from reaching the U.S. border—but then there was little that could be done. There were some unrealistic suggestions for trying to stop or slow the population at the isthmus of Panama, since our military forces still largely controlled the terrain alongside the Panama Canal. In cooperation with SARH, the Mexican Department of Agriculture, our own USDA attempted to create a zone of high concentration of European race managed colonies coupled with intensive swarm removal at the Gulf of Tehuantepec in that narrowing of central America but rugged terrain, a late start and failure to obtain complete beekeeper cooperation proved to be drawbacks.

A very successful interdiction effort was maintained at U.S. ports of entry. Swarms of bees, some Africanized, were discovered and destroyed at many east/west coast and Great Lakes ports. This effort continues today. Since the Africanized bee arrived in the U.S., 18 bee captures, in which the bees were identified as Africanized, mostly in East coast ports, have occurred. A population of Africanized bees accidently transported into the Lost Hills area of California was destroyed after an extensive and expensive eradication campaign that cost over $1 million dollars in that State in 1985. Today Federal USDA, APHIS and virtually all States with ocean ports have a program of interdiction. In my own State of Delaware for example, University, State Department of Agriculture and USDA, have a coordinated pro-

gram at the Port of Wilmington and at the major boat anchorage in the Delaware Bay to attract swarms and destroy such possible alien bee entries before they escape and breed.

It should be noted, human nature what it is, that there was widespread apathy here in the U.S., disbelief of the potential threat and a U.S. beekeeping industry totally consummed with dealing with serious problems of parasitic mites introduced into the U.S. in the mid 80s during this time. A standard "assumption" all along has been—"that is *their* problem, not ours" and the corollary—"we will deal with it *if* or when it arrives." Many have assumed it would not arrive or if it did it would not be a problem.

What is currently being done

A number of efforts are currently underway to deal with the introduction of Africanized honey bees into the U.S. Texas, the first State invaded and one of the most diversified in the beekeeping industry, has had the most experience with the bee. The Texas Department of Agriculture is responsible for the bee program. USDA, APHIS originally had a presence in south Texas but now it is doing less. A USDA, ARS lab just dedicated in Westlaco provides technical support but it is hampered in that it isn't yet at full strength. Significant training programs and an educational effort is underway by Texas A & M and the Texas Cooperative Extension system. Beekeepers and the beekeeping industry are fully involved and supportive in all aspects of the program.

Arizona and New Mexico are less prepared for the Africanized bee. State Department of Agriculture officials will be responsible for the majority of the program. An educational program in the school system and on Indian reservations, although inadequately funded, includes Federal, State and industry efforts to reach school children. One new wrinkle in erradication of feral swarms and colonies now manifest in these drier localities is the tendency of the Africanized bee to proliferate in cities and towns where water is more readily accessible while remaining scare in more arid rural sites. Utility containers such as those for telephone and particularly water service boxes are proving to be very desirable nest sites for this bee—such sites are generally too small for European-race bees.

In California, individual counties will be responsible for Africanized bee programs. Imperial and San Diego Counties have action plans for dealing with the bee and will likely soon be faced with that reality. Other States, some counties and a few municipalities have an Africanized bee action plan, most patterned after the Texas State plan and a national plan developed by scientists, government officials and industry from a series of national meetings. National organizations such as the Apiary Inspectors of America, which are the State government officials dealing most directly with beekeepers, national and regional industry associations, such as the Eastern Apicultural Society that I serve as Chairman of the Board, and State and local beekeeping and entomological organizations have offered educational programs and training for beekeepers, farmers and the general public regarding this bee. I have presented my views and recommendations to countless bee, commodity and civic organizations at every level since my direct involvement with Africanized bees.

Action plans involve removal of swarms and feral colonies where they might cause problems, a quarantine system that permits movement of beekeeper maintained colonies only under certain circumstances and education of the general public about the bee. Training for responsible public officials is available such as African bee ID from USDA, ARS, as are a variety of governmental and commercial training aids. More assistance is needed to permit purchase of and maintenance of bait hives so states/counties/municipalities can more accurately determine the spread of this bee population in areas where it does not yet exist. Additional funding for training and training materials is also needed.

The Texas Department of Agriculture quarantine plan seeks to reduce man-assisted movement of Africanized bee genetic material while assuring beekeepers the opportunity to pursue their livelihood or hobbyist interests. Less than 5 percent of the 100+ stinging incidents in south Texas reported since arrival of the Africanized bee in 1990 have involved beekeeper hives yet used bee equipment is odor-charged and highly attractive to bee swarms. To date, no beekeeper movement of Africanized bee genetic material to other locations in the U.S. has occurred.

Past experience with industry/regulatory attempts to reduce the spread of parasitic bee mites suggest the effort to reduce man-assisted movement of Africanized bees will be an up-hill battle. Our industry is highly mobile and an apparent shortage of bee colonies of adequate strength to meet current pollination needs will mean continuation of this mobility. No State or region is self-sufficient to meet pollination needs or to raise queens/package bees to offset heavy colony losses due to mites and pesticides. Pollination is often perceived of as a "free" service of the bee. Countless

economic analyses demonstrate that not to be the case and beekeepers who operate only as crop pollinators lose money—more money the more colonies rented. Our challenge is to reduce man-assisted movement of this bee while protecting the availability of bees to meet crop pollination needs.

Suggestions for future actions

Federal involvement beyond the current level is needed for the Africanized bee. USDA, ARS in conjunction with USDA, ES (extension) and CSRS (Cooperative State research) has conducted and continues to perform excellent research, training and educational efforts with the Africanized bee. There is need for expansion of all of these functions. Target audiences include beekeepers and the bee industry, State, county and municipal authorities (elected and non-elected that now or in the future will have to deal with this alien introduced species) and the general public that may face accidental encounters with defensive behaviors of Africanized bees.

A high priority for dealing with Africanized bees is to reduce man-assisted movement of Africanized bee genetic material while protecting the availability of honey bee colonies for pollination of crops and allowing beekeepers a reasonable opportunity to pursue their business or hobbyist interests. This is a formidable challenge and a contradiction to how parasitic bee mites and introductions of other alien insect species programs have functioned.

Possible ports of entry and isolated geographical enclaves such as the Islands of Hawaii and Puerto Rico need continued interdiction efforts and continued destruction of accidental invaders. Since the population of Africanized bees is both external to our shores and also currently within three States (and likely to continue to expand its range into additional U.S. territory), the possibilities of man-assisted spread has expanded making the task more difficult.

Federal assistance is needed to help monitor the spread of Africanized bees within the U.S. Currently, USDA, ARS assists in training on Africanized bee ID and in ID confirmations for APHIS intercepts. USDA, APHIS initially assisted with trapping swarms at monitoring stations in south Texas but has now withdrawn. It was unclear, at least to many of us outside of the Federal Government, what role APHIS would assume after the Africanized bee population reached the U.S. This in part hampered other governmental and non-governmental agencies for establishing their territories as part of the solution puzzle, due to this major player holding a stage it eventually has seemingly abandoned. Assistance in the form of a cooperative trapping program or, as a minimum, purchasing of traps and pheromone lures for State deployment is recommended.

USDA, ARS, ES and CSRS all have training and educational programs but their outreach is limited. One program need is to reach youngsters to teach them about the need for bees and avoid having bees become part of the mindset that "the only good bug is a dead bug." Recently the American Association of Professional Apiculturists (AAPA), of which I am a member, has assisted with a contribution to Arizona for a public school and native American bee education program. Kits are available for further distribution but funds are needed to expand this worthwhile effort.

I have pointed out that research is still needed to provide answers. The lead USDA, ARS bee lab for Africanized bee studies is short two scientists. There has been a shift of funding from research to implementation in the U.S. resulting in less funds to find solutions. State and industry sources are not adequate although they help. Just this year, my group, the Eastern Apicultural Society established a foundation, primarily from member contributions, to fund honey bee research to help fill the gap. Producers of crops that rely on honey bees for pollination have been supportive and have funded bee studies.

The mechanism that seems to be most effective in reducing man-assisted movement of Africanized bees is establishment of a quarantine zone. So far this has been done only in Texas which had in place an action plan to deal with the Africanized bee before its arrival. Now with multistate distribution we need Federal involvement. A national conference of USDA–NASDA (National Association of State Departments of Agriculture) sponsorship held in 1991 was directed toward development of a national certification plan. Now seems an appropriate time to again get all segments of the industry together with governmental and research agencies to listen to what is working in Texas and develop a workable, effective national action plan for Africanized bees.

Finally this recommendation—although the Africanized bee is not your standard non-indigenous species, it represents a significant danger, as does the invasion of many other alien plant and animal species. Only with a strong effort by dedicated employees in the trenches and enlightened supervision at field and top administration levels, can we spend our tax dollars wisely. Money spent now to keep an alien

species out or to reduce further distribution of a natural non-native population once established, such as the case in the Africanized honey bee, saves money in the long run and reduces the possibility of greater environmental contamination while better protecting the health of the general population.

PREPARED STATEMENT OF DON C. SCHMITZ

Senator Akaka and Members of the Committee: Thank you for the opportunity to appear before you to make a statement concerning the Florida Department of Environmental Protection's views on Federal policies governing the introduction of non-indigenous plant and animal species.

Try to visualize with me for a few moments that unique ecosystem in south Florida known as the "Everglades." Picture in your mind its large expanses of native sawgrass, its beautiful tree island hammocks, its slow, vast southern sheet flow of water, its rare and endangered wildlife—the snail kite, the Florida panther, and the American crocodile. Visualize the millions of birds that call this ecosystem home. Try to understand the importance of this ecosystem with its bio-diversity, not only to the fish and wildlife, but to the citizens of southern Florida who depend upon its water for life. Without it, the magnificent Florida Bay becomes an aquatic desert, too salty to be a nursery for millions of marine organisms that are so vital as a food source for both wildlife and humankind. And finally, try to visualize the economic importance of this unique place, not only for its natural resources, but for its importance as one of the prime tourist destinations in all of the world. It has been designated a world heritage site, international biosphere reserve, and wetland of international importance.

Now with this picture firmly in mind, picture if you will a fleet of gigantic bulldozers slowly crawling their way across the vast expanses of the Everglades. As they move, they destroy everything in their paths—the wetlands are filled in, the waters are drained, the birds and animals are driven out, and their food sources are forever lost. Imagine if you can, this slow and certain armada completely destroying the Everglades in the course of a few short years. This scenario is the equivalent of what is happening in the Everglades at this very moment as a result of the invasion by the alien melaleuca trees.

The Australian melaleuca tree (*Melaleuca quinquenervia*), first introduced into southern Florida for its "swamp-drying abilities" around the turn of the century, is rapidly invading what remains of the Everglades wetland system at an estimated rate of 50 acres per day. Dense melaleuca forests almost totally displace native vegetation and its associated wildlife, resulting in a catastrophic loss of biological diversity in these areas. Worse, the melaleuca tree is a thirsty tree using four times more water than the native grasses it displaces in the Everglades. Water is vital to the Everglades, and the loss of valuable water resources will only increase as melaleuca continues its relentless spread. This will threaten not only the ability of the Everglades and Florida Bay to survive, but also the ability of the Biscayne aquifer (which underlies an area of 3,200 square miles in Dade, Broward, and Palm Beach Counties) to recharge. It is the sole source of fresh-water along this highly populated coast. Left unchecked, the melaleuca invasion in the Everglades will destroy this "river of grass," despite past and present efforts to preserve it for future generations.

More than 900 species of alien plants have become established in Florida, the majority of which are found in the State's wetland and upland forest ecosystems. Almost one half of these alien plants were intentionally imported as landscape ornamentals, contaminants of agricultural practices, or as potential sources of food, timber, fiber, and forage. Many of these biological pollutants were imported, promoted, and released into Florida's environment by Federal agencies. The United States Soil Conservation Service, the United States Army Corps of Engineers, and the United States Department of Agriculture (USDA) played pivotal roles in introducing and helping to spread many of the invasive alien plants that presently plague Florida's natural areas. Present estimates indicate that more than 2½ million acres of Florida's remaining natural areas have become infested with non-native plants. These alien plant and animal invasions can alter the very fabric of native ecosystems. It can change them from once highly diverse biological systems to bland, monospecific structures.

Most Floridians, as is the case with most Americans, are unaware of the severe ecological damage that invasive alien plant and animal species are causing in the natural environment. Additional invasive alien plant species are invading Florida's waterways and what remains of its natural coastal areas. Hydrilla (*Hydrilla verticillata*), a submersed vine-like plant from Ceylon, is fouling, clogging, and de-

stroying 75,000 acres of Florida's lakes, rivers, and streams. It continues to spread and to infest new water bodies. Along the coastlines of southern and central Florida, Australian pine trees (*Casuarina* spp.) heavily infest both the east and west coasts of the undeveloped portions of barrier islands. Besides totally displacing native beach plant communities, the dense shallow root systems of Australian pine trees interfere with the ability of endangered and threatened sea turtles to excavate suitable nesting cavities.

Since invasive alien species don't respect jurisdictional boundary lines, good coordination is essential in managing these destructive species. The Florida Exotic Pest Plant Council, a non-profit organization, was established in 1984 and has helped coordinate what meager funding resources have been available in Florida to combat this menace in wetland and upland forests on both State and Federal lands. However, there is a desperate need for funds to manage and to find long-term solutions to the environmental problems caused by these species. For example, we are only capable of managing one half of the melaleuca populations in the Everglades because of lack of funding. The U.S. Fish and Wildlife Service has no dedicated funding source to manage its vast melaleuca populations (20,000 acres) in the Loxahatchee National Wildlife Preserve, the northern headwaters of the Everglades. Everglades National Park needs an additional $325,000 to establish an alien plant control program within the park, and to continue support of a regional multi-agency management and biocontrol effort. Funding for a long-term solution, such as finding biological control agents to stop the spread of melaleuca, has been tenuous at best.

The State of Florida applauds the efforts by the State of Hawaii in attempting to protect their island State from the introduction of invasive alien plant and animal species. However, this is not an exclusive environmental problem found only in Florida and Hawaii. Large expanses of wetlands in the northeastern United States, southeastern Canada, the midwest, and in scattered locations of the western United States have been overrun and lost to a contaminant of European ship ballast, the purple loosestrife plant (*Lythrum salicaria*). In the south, the oriental kudzu vine (*Pueraria lobata*), which was spread by the United States Soil Conservation Service in the 1930s (government incentives were as much as $8 an acre for farmers to plant it), has drastically decreased biological diversity in millions of acres of forested land.

Now, what can the Federal Government do about this ecological catastrophe that is slowly engulfing our Nation's remaining natural areas? Although the State of Florida acknowledges its own responsibility to deal with this problem (a study was recently initiated by the Florida Department of Environmental Protection that will make recommendations to Florida's legislature for the establishment of a comprehensive program for the research into and control of alien plants and animals that are invasive to public lands), there are things only the Federal Government can do. It is imperative that we "turn off the spigot" of new invasive alien plant species. Presently, there is no screening of plant or animal species by the USDA for their potential invasiveness in our Nation's natural areas. For example, unless they are listed as Federal Noxious Weeds, foreign plants can easily be introduced. At least 750 weeds meeting the Act's definition remain unlisted. If it wasn't for the valiant efforts by Congressman E. Clay Shaw from Ft. Lauderdale, melaleuca would have never been listed as a Federal Noxious Weed by the USDA. Secondly, no one is in charge. It is imperative that a lead Federal agency be designated to identify problem areas, and to provide general oversight and funding help in the development of State and Federal management programs. The Florida Department of Environmental Protection endorses the proposed changes to the Federal Noxious Weed Act that have been made by the Weed Science Society of America, the National Plant Board, and the Natural Resources Defense Council.

Billions of dollars have been spent in the United States to buy environmentally sensitive areas to protect them from pollution and development, yet the biological heritage to be preserved for future generations is being overrun and lost to non-indigenous species. This is especially true in Florida.

PREPARED STATEMENT OF HOWARD M. SINGLETARY, JR.

I would like to thank you for the opportunity to appear before you and testify about the significant impact of the introduction of non-indigenous plant and animal species to the United States and directly to North Carolina. Since the major focus of my 30 year career has been spent working in the area of plant pest exclusion and regulatory agriculture, I possess a unique perspective that will hopefully be of benefit to you in your deliberations. My comments represent the views of the State of North Carolina, the Weed Science Society of America (WSSA) of which I am a member and have recently served as Chairman of the Federal Noxious and Invasive

Weeds Committee, the Intermountain Noxious Weed Advisory Council (INWAC) and the National Plant Board (NPB). The WSSA is composed of weed scientists in the academic community, private industry, regulatory and public service industry and private practitioners with a membership of approximately 2,300 members. INWAC is a voluntary organization with membership from public and private sectors mainly representing western States, whose function is to serve as a liaison between States, Congress, Federal agencies and trade associations on issues regarding noxious weeds. The NPB is composed of State plant pest regulatory officials from all 50 States and Puerto Rico.

According to the U.S. Congress, Office of Technology Assessment on *Harmful Non-Indigenous Species in the United States,* there are at least 4,500 species of foreign origin that have established populations in this country. Many of these non-indigenous species including wheat, soybeans and cattle have played a significant role in U.S. agriculture as we know it today. However, approximately 15 percent of all non-indigenous species have been documented to cause severe harm. In many cases, species have been introduced from distant geographical areas into the United States. When these species are placed into new areas lacking environmental and biological restraints of previous habitats, their aggressive behavior may allow them to become serious pests in agricultural, rangeland, wetland or aquatic systems.

The economic, health, and environmental costs due to the presence of plant pests are staggering. I would like to highlight examples of weed and insect pests in agriculture, forestry and natural areas which serve as indicators of the problems we are experiencing today.

Weeds compete directly with agricultural crops by reducing quantity and quality and increasing overall weed management costs. According to the estimates derived from the Weed Science Society of America *Crop Losses Due to Weeds—1992,* losses directly attributable to non-indigenous weeds are estimated to range from $3.6 billion to $5.4 billion dollars annually. This calculation does not include environmental, human health, regulatory and other indirect costs associated with non-indigenous species estimated to be an additional $1 billion dollars annually. Witchweed (*Striga asiatica*) is a semiparasitic plant that attacks corn, sorghum, and sugarcane reducing yields and restricting movement of commodities to other areas. This non-indigenous species was detected on more than 430,000 acres in the States of North and South Carolina in the late 1950's. Without direct intervention, this pest represented a direct threat to corn growing areas of the United States. A cooperative eradication project initiated by the USDA–APHIS, PPQ, North Carolina Department of Agriculture and the South Carolina Department of Plant Industry has been successful in reducing the infested acreage to 38,000 acres. Direct costs associated with this weed to date have exceeded $150 million dollars.

There are numerous examples of introduced insect pests causing serious threats to agricultural production. The Mediterranean fruit fly (*Ceratitis capitata*) is considered one of the most destructive pests of citrus and other tropical and subtropical fruits. Once established, this insect is capable of interrupting trade from the United Stats to citrus growing areas in other parts of the world. Annual losses of up to $897 million in damaged produce, control, and reduced export revenues have been documented in several outbreaks in California alone.

The European Gypsy Moth (*Lymantria dispar*) (EGM) was accidently released in Massachusetts in 1869. Since then the gypsy moth has spread throughout New England, south to Virginia and northeastern North Carolina and west to Michigan. The Asian Gypsy Moth (AGM) was first detected in North America in British Columbia (Canada) and the States of Oregon and Washington (U.S.) in 1991. During 1993, the Asian Gypsy Moth was again introduced to the United States into eastern North Carolina from Germany on shipments of military munitions. This strain is actually a hybrid strain with DNA characteristics of both the AGM and the EGM. The introduction of this insect into North Carolina represents a threat to forests and urban areas of the State by causing tree death, alteration of species composition in natural ecosystems and directly impacting the landscape. An eradication effort is planned for this pest in North Carolina with program costs projected to be $9.4 million over a 3 year period.

On a national level, laws and regulations addressing non-indigenous species are disjointed with responsibility for administration, implementation, control and regulatory functions spread over 21 agencies. In the current scheme, one specific agency may have responsibility for control or eradication programs while others address movement into the United States or interstate movement. This patchwork of agency involvement has prevented, in many cases, a prompt and timely reaction to the introduction of non-indigenous species thus allowing a prime opportunity for their full establishment and subsequent spread.

In order to address the problem of non-indigenous species, there must be a coordinated effort at the Federal level to identify pest problems at an early stage and prevent their entry. In order to locate infestations at this level, Federal agencies must improve current survey and detection techniques. Intentional and accidental introductions must be monitored extensively at ports of entry by properly trained and technical personnel. At this small scale, there is a possibility of eradicating the population prior to the time it escapes thus eliminating the need for additional or extensive pesticide applications. To accomplish the objective of early intervention and prevention, adequate and stable funding must be established enabling Federal agencies to address non-indigenous species on an emergency basis.

Policy issues as outlined in the recently released OTA Report and by the USDA–APHIS, PPQ Weed Policy Steering Group in their departmental recommendations represent a shift to a more holistic approach in reacting to the introduction of non-indigenous plant and animal species in the United States. One area that cries out, in my opinion, for more attention and funding is the area of noxious weed introductions. Considering the full impacts of non-indigenous species, weeds have far more impact from an economic perspective on agricultural and natural ecosystems than any other pests. Presently, they receive less attention because they do not creep, crawl, or fly and in many cases take longer to establish and begin to proliferate.

In the near future, I hope there will be cooperation in Congress to revise the Federal Noxious Weed Law granting full authority to react promptly to the introduction of non-indigenous weed species. Without careful and deliberate attention, I feel the rich plant and animal diversity so much a part of our natural habitats will be lost to non-indigenous species. I urge you as Members of Congress to review these issues and take appropriate actions.

PREPARED STATEMENT OF DR. JAMES T. CARLTON

Our coastal waters—our estuaries, bays, ports, harbors, rocky shores, salt marshes, sandy beaches, sounds, and many other habitats—are now the home of hundreds of species of exotic marine, brackish-water, and freshwater organisms. These invasions continue into 1994 in a biological "game" of ecological roulette:

- In the Pacific Northwest, where once were vast areas of critical open habitat on upper intertidal bay shores, are now equally vast meadows of the Japanese eelgrass, *Zostera japonica.* Open flats are now rooted vegetation, a profound change that can dramatically alter the distribution of native animals and plants, the accumulation of sediments, and potentially soil chemistry.

  The Japanese eelgrass was accidentally introduced in the 1940s or 1950s with shipments of Japanese commercial oysters.

- In many parts of San Francisco Bay it is now difficult if not impossible to find native species. Over 200 species of exotic animals and plants are now found from the Golden Gate to the shipping channels of Sacramento, and from the marshes of Vallejo to the lagoons of San Jose. In some parts of San Francisco Bay, guidebooks to the marine life of Japan and to the marine life of New England are all one needs to identify the common species.

  Sea anemones, snails, sea squirts, sponges, seaweeds, and a vast variety of other organisms were brought to San Francisco Bay on the bottoms of Gold Rush ships in the 1850s, and these invasions continue today in the ballast water of global ships in the 1990s. Many other species were inadvertently transported to the Bay with Atlantic and Japanese oysters. How the Bay "works"—everything from the food webs and the energy flow to the geology of the bay shores—has been profoundly changed by these invasions.

- A boat mooring—a long piece of ½" nylon line, for example—hauled up in Long Island Sound is covered with luxuriant growths of 6"-long brown seasquirts and 12"-long mats of thick green seaweed. Sprinkled here and there are large orange patches of another seasquirt, and little orange-striped sea anemones poke out from within this fouling matrix. A third type of opaque white seasquirt is squeezed in every possible crack.

  The brown seasquirts are *Styela clava,* the introduced Asian species that may have displaced many populations of our native mussel *Mytilus edulis.* It reached our shores on boat bottoms from Europe in the early 1970s. The orange seasquirts are *Botrylloides diegensis,* inadvertently introduced from California by an experimental scientist; it too arrived in the early 1970s. The green seaweed is the Asian algae *Codium fragile tomentosoides*—first found at Montauk Point, New York, in 1957, and now found from Maine to North Carolina. The sea anemones are the Japanese *Haliplanella lineata*—an older

introduction from the 1890s. And the opaque white seasquirt is the latest addition—the European *Ascidiella aspersa,* which seems to have newly appeared in the mid- to late–1980s. The Asian species arrived on our Atlantic seaboard presumably on boat bottoms—but the new European seasquirt may be a ballast water introduction. Scientists are not immune to moving species around, and the orange California seasquirt appears to represent such an example in our marine waters. It is probable that sampling this community a few years from now—or tomorrow—would reveal another new invasion. These massive populations of seaweeds and sea squirts coating marine installations can have an extensive economic impact—and can alter dramatically the abundance of native species.

No coastal State or possession in the United States is now free from invasions—nor is any region immune to future invasions. The long legacy of maritime commerce and other activities has left us with often extensive accumulations of exotic species from around the world. The pace of these invasions appears to have increased dramatically at the end of the 20th century. The lessons of past invasions dictate that as long as a transport corridor for non-indigenous species is in place, the potential for future invasions is high—invasions that include predators, competitors, diseases, and pathogens.

In many cases, these exotic species do not come to the attention of public or political arenas. Such species are the interests and concerns of scientists—but since many of these species appear to have no immediate, direct, and profound human impact, they remain of relatively little concern outside the world of scientists. In turn, this means that the mechanisms that brought these species to our shores continue unabated, and with every new spin of the exotic species roulette wheel a non-indigenous animal and plant with vast potential for altering human society could be released. The wheel spins every hour, 24 hours a day, for our aquatic communities.

Research in my laboratory on ballast water and sediments indicates that, without controls, there will be new invasions into United States waters—waters that support important fisheries, navigation, and recreation—of exotic aquatic animals and plants from Europe, Asian, and other countries, equal to or exceeding the impact of the zebra mussel.

Under current U.S. law, ballast water must be exchanged before entering the Great Lakes. That is, ballast water from a foreign port must be deballasted and the ship reballasted on the high seas. Thus, water released into the Great Lakes would have a vastly reduced probability of leading to invasions by freshwater organisms. Additional law soon extends this provision to the Hudson River. When a vessel is bound for freshwater ports of the U.S., this exchange process has the added advantage of the ocean salt water killing any freshwater organisms that may remain in the ballast tanks after the exchange process.

At the present time U.S. law does not require vessels from foreign ports to exchange their water if bound for ports other than in the Great Lakes (or Hudson River). The current absence of Federal law has led and is now leading a number of States to determine what actions can be taken at a regional level. However, even if such laws were in place—and it is critical that we look in that direction—we also now know that ballast exchange is only the first preliminary step in the prevention of exotic aquatic invasions of harmful species.

Ballast exchange is almost always only partially achieved—it is most often impossible to release all water from a ship before needing to reballast. Thus, vessels from foreign saltwater ports bound for U.S. saltwater ports which have in fact attempted ballast exchange will thus almost certainly continue to release some of their original water (and animals and plants therein) anyway—and in these cases the process of reballasting with high seas saltwater will of course not kill the remaining saltwater organisms. We believe this is a serious hole in ballast water control—because of the potential shortfalls in saltwater-to-saltwater port transport, all of our coastal ports are clearly at great risk from invasions, even if ballast exchange were in place for our coasts.

In addition, many vessels cannot and would not exchange their water during storm conditions—conditions that can prevail on the open ocean for perhaps half the year or more.

These and other considerations mean that while ballast water exchange is a good first step, "real" control efforts will mean studying other ballast water management scenarios, demonstrating and implementing ballast water management technologies in order to insure "environmentally sound" ships of the future. The recently completed "Shipping Study", mandated under Public Law 101–646, through the U.S. Coast Guard, has outlined many of these options, which now need to be critically examined for potential implementation.

I am hopeful that with progress in ballast technologies, and with the cooperation of shipping and allied industries that have already expressed great concern about exotic invasions, we can very significantly reduce the threat of future invasions of exotic organisms by ballast water.

PREPARED STATEMENT OF FAITH THOMPSON CAMPBELL, PH.D.

Thank you, Mr. Chairman, for the invitation to testify here today on the impacts of alien or non-indigenous species in the United States. The Natural Resources Defense Council (NRDC) is a public interest environmental organization of 170,00() members and supporters. We have studied and carried out policy advocacy regarding efforts to curtail the impacts of alien species since 1987.

Because of the expertise of some of the other members of this panel, I will focus my statement on losses caused by alien or exotic pests of North American trees. These losses have been significant in monetary, ecological, and aesthetic terms. For a more detailed description of these introduced pests and their impacts, see the attached report, *Fading Forests.*

It is most important to remember, however, that a comprehensive program could restore many of our tree species—and with them the health of our forests and the beauty of our city streets, parks, and yards. The NRDC thanks the Committee on Governmental Affairs for its leadership on this important but under appreciated issue, and looks forward to working with you to bring about an effective National program to counter all invasive alien organisms.

TIMBER LOSSES

About $2 billion in timber revenues has been lost to tree mortality or morbidity caused by alien pests (Pimentel 1986). Trees virtually eliminated as timber supplies include chestnut (*Castanea dentata*), American elm (*Ulmus americana*), butternut or white walnut (*Juglans cinera*), and Port-Orford-cedar (*Chamaecyparis lawsoniana*). In 1989, Port-Orford-cedar brought an average price of over $2,600 per thousand board feet (compared to $530 per thousand board feet for Douglas-fir). The value of POC logs exported 1980–1990 was over $195 million (Warren 1990).

Expensive pest control, tree improvement breeding, silvicultural controls, and other programs have been needed to maintain harvest levels of red pine *Pinus resinosa,* white pines (*Pinus,* subgenus *Strobus*), and the oaks (*Quercus* spp.). Pennsylvania lost $40 million in trees to gypsy moth (*Lymantria dispar*) infestations between 1972 and 1980 (Virginia).

Potential losses are far higher A risk assessment team estimated impacts of between $25 million and $58 billion to commercial timber in the west if alien pests were to be introduced on logs from Siberia (USDA Forest Service 1991b). A second team put timber losses associated with introductions of pests from New Zealand at between $52 and $364 million (USDA Forest Service 1992). Neither of these estimates includes costs associated with loss of jobs, recreational amenities, or ecological values.

RECREATION

Gypsy moth-infested areas experience up to a 20 percent reduction in recreational use (Goebl 1987). The beauty of many of the same woods in the spring is now diminished by the devastating impact of Dogwood anthracnose (*Discula destructiva*) on the flowering dogwoods (*Comus florida*). Dogwood anthracnose has killed over 80 percent of the trees in some areas of its extensive range (U.S. Forest Service 1991a). From Pennsylvania to New England, millions travel to the mountains to view the sugar maples changing to crimson. Defoliation by the pear thrips (*Taeniothrips inconsequens*) discourages such visits. An estimated $25 billion was spent by Autumn tourists in Vermont alone in 1992 (Guertin).

ORNAMENTALS AND OTHER PRODUCTS

The American elm was once the primary ornamental tree in eastern and midwestern cities. Within 50 years, Dutch elm disease, caused by an introduced fungus *Ophiostoma* (=*Ceratocystis*) *ulmi,* had killed 75% percent of the elms in the Northeast by 1979 (USDA Forest Service 1991b). Cities with large elm populations have suffered more than an aesthetic loss. The removal of dead and dying elms has cost up to an estimated $100 million per year nationwide (Mazzone and Peacock 1985).

Before the spread of the root disease caused by the fungus *Phytophthora lateralis,* Port-Orford-cedar was also widely used in ornamental plantings (Kliejunas & Adams, 1981). This use was largely abandoned by 1960 (Roth *et al.* 1972). Direct

losses to nursery owners in the 1950s approached $1 million, not including loss of future sales (Zobel *et al.* 1985).

Dogwoods and hemlocks are extensively planted. Well-maintained landscape plants can usually survive attack by the alien pest, but the homeowner or park manager may have to pay for pesticide applications. More importantly, the genetic base for continuing horticultural developments is severely eroded.

Fraser fir is increasingly popular as a Christmas tree. This species, along with balsam fir and Douglas-fir, make up about thirty-five percent of national market—which sold more than 35 million trees in 1993 (Grimsley).

Americans spend nearly $35 million annually on maple syrup which is made from the sap of the sugar maple (Anonymous).

MITIGATION COSTS

Efforts to eradicate or suppress exotic pests vary from year to year, in response to perceived emergencies. Thus, in fiscal year 1992 The Animal and Plant Health Inspection Service (APHIS) alone spent $20 million on efforts to eradicate the Asian gypsy moth near Pacific coast port cities (McGovern, personal communication). In fiscal year 1993 *total* expenditures by agencies of the U.S. Department of Agriculture did not quite reach $19 million. Of this total, the Forest Service spent $14.5 million (Lorimer, personal communication; Smith, personal communication; and Miller, personal communication). APHIS spent $2.25 million (McGovern, personal communication). The Agricultural Research Service spent $350,000 on research on dogwood anthracnose and $1.9 million on gypsy moth research (Faust). Over two-thirds of all USDA tree pest control funds in FY1993 were aimed at suppression or eradication of the European gypsy moth.

While I have not completed analysis of FY94 fiscal data, the distribution is probably about the same. NRDC believes that this skewed funding has resulted in inadequate attention to other pests which threaten to cause the extinction of certain species or severe ecological disruption.

In fiscal year 1994, the Forest Service' Forest Insect and Disease Research program increased its spending on exotic pest research significantly—from $1.23 million to $6.966 million (Smith). The Administration has proposed spending $7.136 million in fiscal year 1995. For Forest Pest Management in fiscal year 1995, the Administration has proposed spending a total of $15 million on gypsy moth suppression and eradication; and up to $2.3 million on a combination of pests which includes all other exotic pests as well as some native pests (Jones).

Over time, these expenses add up. In an effort to curtail the spread of white pine blister rust, $100 million dollars were spent pulling out gooseberry (*Ribes* spp.) bushes or spraying them with herbicides (USDA Forest Service 1991b). However, these efforts failed to stop the spread of the disease in the West. This approach has proved more successful in eastern North America (Ostrofsky *et al.* 1958).

ECOLOGICAL IMPACTS

According to Ledlig (1992), "Introduction of exotic diseases, insects, mammalian herbivores, and competing vegetation has had the best-documented effects on genetic diversity [of forest ecosystems], reducing both species diversity and intraspecific diversity." Their impact has been greater than that of other, more widely recognized, human-caused factors, including forest fragmentation, changed demographic structure, altered habitat, pollution, and favoring of certain "domesticated" species of trees.

More than 60 percent of the 165 million forested acres in the Northeast have been seriously damaged by introduced insects or pathogens (Burkman, *et al.*). There has been little research on the potentially serious effects on wildlife of eastern forests from the loss of nuts and berries formerly produced by vanishing tree species such as the chestnut, butternut and—in many areas—dogwood, and reduced populations of oaks and American beech. The ecological consequences of hemlock eradication could be profound, especially for stream temperatures and siltation loads.

A high proportion of the remaining "old-growth" forests in the East consists of steep creek valleys populated heavily by eastern hemlock (*Tsuga canadensis*) (Davis)—which is likely to be eliminated from much of its range in the near future by the hemlock woolly adelgid.

Eighty to ninety percent of the whitebark pine (*Pinus albicaulis*) trees in Glacier National Park and the Bob Marshall Wilderness are infected by white pine blister rust (Schmidt 1992). Whitebark pine seeds are a major food source for the grizzly bear, black bear, red squirrel, and Clark's nutcracker (Kendall and Arno 1989; Schmidt 1992).

"The wholesale killing of American chestnut by blight on thin soils on upper slopes in places in Pennsylvania has in some instances resulted in soil deterioration . . . and centuries may be required to restore the original value of the watershed." (Boyce) The dogwood's leaves contain a large amount of calcium and are important in building rich soils (Hepting 1971). In Oregon and California, Port-Orford-cedar's leaf litter is less acidic and higher in calcium than that of associated conifers, thus probably contributing to desirable soil properties, particularly on ultramafic (serpentine) sites (Zobel *et al.* 1985).

Some of the most threatened trees form the foundation for unique micro-ecoystems. The Fraser fir occupying the highest peaks in the southern Appalachians provides essential habitat for the very rare spruce fir moss spider and several rare bryophytes. These species, and probably many more endemic invertebrates, are in jeopardy of becoming extinct with the fir (Langdon). Port-Orford-cedar forests in southern Oregon and northern California form ecologically and floristically unique communities (Zobel *et al.* 1985).

POTENTIAL FUTURE INTRODUCTIONS

New attention is being directed toward introduced forest pests because of the likelihood that American firms will greatly increase imports of logs or rough-cut lumber in large quantities from other temperate regions to substitute for logs no longer being cut in our National forests. Such imports pose a real threat of introducing additional damaging forest pests. A risk assessment team that examined proposed imports from Siberia estimated losses associated with the possible introduction of just 36 "representative" pests of larch (out of 175 pest species identified), at between $24.9 million and $58 billion. These figures represented only the potential impacts to commercial timber species in the western United States; they did not consider ecosystem damage or impacts to nonconsumptive industries associated with forested land.

The Siberian team stated further:

> Loss of a significant proportion of living trees within stands would trigger complex changes in food supply and habitat . . . Detrital food chalns—fueled by dead organic matter—would be favored, while food chains that depend on living trees would collapse unless the system recovered very quickly. . . ." USDA Forest Service 1991b).

The risk assessment authors predicted that mycorrhizal fungi, several species of voles, flying squirrels, and spotted owls would be seriously harmed Deer and elk would be further limited by the increased scarcity of closed-canopy forests, which provide winter forage and shelter. Western yew, accipiter hawks, and salmonid fish would also decline (USDA Forest Service 1991b).

Potentially damaging pests—either not now present in North America or present but possibly of different genetic makeup—were also identified in New Zealand and Chile. These two countries are currently the principal sources of large-scale wood imports—other than Canada.

RECOMMENDATIONS

For many years, it has been recognized that the most efficient method to eliminate exotic pest infestations is to prevent the organism from entering the country. That task belongs to the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture.

Quarantines are never completely effective; they often delay rather than completely prevent introductions. Nevertheless, such delay is worthwhile because it "defers damage or costly readjustment to the intruder [and] also because the new disease can likely be met in the future with a more organized and efficient effort than is possible now." Quarantines are especially important to forestry because of the long period before trees reach maturity, thus slowing development of disease-resistant strains (Boyce 1961).

Unfortunately, the evidence is that APHIS' current efforts are not as effective as they should be. Sometime before the 1990s, an alien leaf rust which attacks poplars and conifers (*Melampsora larici-populina*) was introduced on our West coast (Chastagner and Newcombe 1993). Black cottonwood *Populus trichocarpa* and aspen (*Populus tremuloides*) and hybrid poplars are commercially important as a potential source of biomass for conversion to alcohol for fuel and for blending with conifers in the production of high-grade paper (Abelson; Chastagner and Newcombe 1993).

The common (or larger) pine shoot beetle (*Tomicus* (= *Blastophagus*) *piniperdia*) was discovered in 1992 near Cleveland, Ohio (Kucera 1992). This pest has attacked a variety of Eurasian and North American pine species. Infestations have been found from western New York through Pennsylvania, Ohio, Indiana, to Illinois, as

well as in Michigan. APHIS has quarantined movement of logs, Christmas trees, and nursery stock of coniferous species from the infested states.

A spruce beetle *Ips typographus* was discovered in Erie, Pennsylvania in 1993 (Hofacker 1993). "This insect is one of the most destructive pests of spruce in Europe; one outbreak destroyed an estimated 30 million cubic meters of wood. The beetle also killed millions of trees in Japan." (Smith). APHIS and the Forest Service are searching to determine whether the beetle has become established in the area (Hofacker 1993).

Indeed, Forest Service staff have documented over 300 species of exotic pests, insects and diseases, that have been introduced to North American trees, tree nurseries, and wood products (Millers *et al.* unpublished manuscript and personal communication).

APHIS must not weaken existing regulations on importation of nursery stock (the apparent or known source of eight introductions—See Appendix B). APHIS must also move ahead in adopting at least equally stringent regulations governing log and other unprocessed wood imports. Greater attention should be given to fungi and other pathogens, which appear to pose a greater threat than do insects, APHIS' traditional emphasis.[1]

APHIS should ensure that its regulations adequately address two problems highlighted in the Chilean risk assessment: the prevalence of bark-inhabiting insects on "de-barked" logs and the apparent frequency with which pests are transported on dunnage, crates, or pallets (USDA Forest Service 1993).

Furthermore, APHIS and the Forest Service should study virulent diseases and arthropods in their native countries and apply that knowledge to delay as long as possible their introduction here and to combat them effectively when they do arrive (Boyce 1961). For example, APHIS should expand its monitoring of gypsy moth populations from Siberia to Europe, where Asian or hybrid gypsy moths are now present In many cases, such studies will require multi-disciplinary risk assessment teams similar to those which evaluated possible pest risks associated with wood imports from Siberia, New Zealand, and Chile.

Responsible agencies must be constantly vigilant First, it is often impossible to predict in advance which foreign organisms will prove devastating if introduced. The two Asian fungi that have virtually eliminated the American chestnut and the American elm from the forest cause relatively minor damage to many of the Asian chestnuts and elms which are their natural hosts (Lattin; APHIS 1994).

Second, pest organisms can evolve more virulent strains. Since arriving in America, Dutch elm disease has evolved more aggressive strains which now are spreading in North America (Burkman, *et al.*) and adding to the threat in Europe as well (USDA Forest Service 1991b). The European strain of Scleroderris canker (*Ascocalyx abietina* = *Gremmeniella abietina*) has apparently replaced the less virulent "North American strain" (Skilling). While the outbreak of the 1970s has now subsided with changes in weather and the killing of the lower branches where infection first occurs, damaging outbreaks may resume in the future.

Insects can vary in their virulence—the Asian and hybrid gypsy moths are both more mobile and eat a greater variety of trees than do European gypsy moths. Insects can also switch hosts. The pear thrips has proved able to shift from fruit trees—which are in the rose family (Rosaceae)—to the sugar maple *Acer saccharum*—in the maple family (Aceraceae).

New Zealand has stringent pest-exclusion programs. Because of documented illegal imports of raw wood in "full container load" shipping containers, New Zealand adopted the Forest Produce Import and Export Regulations in 1989. This statute requires prior notice to the quarantine officer of estimated time of arrival of any vessel importing forest produce, and provision of a full manifest (including any pallets). Forest produce is defined to include timber and dunnage; dunnage does not include packing cases or pallets. If a quarantine inspector were to suspect infestation, he or she may require quarantine and treatment according to an appropriate prescription. The costs of inspection, excluding dunnage inspection, such as transport to a quarantine facility, treatment, etc. are paid by the importer (New Zealand).

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[1] Examples of introduced diseases which have or are now causing serious decline of species include: Chestnut blight *Crypphonectria parasitica* (Murrill); "Dutch" elm disease *Ceratostomella ulmi* (Buisman); White pine blister rust *Cronartium ribicola* (Fischer); Scleroderris canker *Acocalyx abietina* (Lagerberg); Dogwood anthracnose *Discula destructiva* (Redlin); beech bark disease *Nectria coccinea* var. *faginata* (Lohman, Watson & Ayers), butternut canker *Sirococcus clavigignenti-juglandacearum,* Port-Orford-Cedar root rot *Phytophthora lateralis* (Tucker & Milbrath). Truly damaging exotic insects do occur; examples include the balsam woolly adelgid, hemlock woolly adelgid, and probably the Asian strain of gypsy moth.

The Forest Service should increase efforts to reduce the damaging effects of exotic forest pests already present as well as to reduce the likelihood of importing additional exotic species. The threat warrants increased funding and personnel. However, equally important is improved integration to spur creative thinking and avoid duplication. Forest Service personnel should work collaboratively with state forestry divisions, private woodlot owners, the academic community—including entomologists, mycologists, tree improvement specialists, ecologists—wood product users, the nursery industry, conservation organizations, and citizen organizations such as the American Chestnut Foundation. It is also important to ensure greater flexibility to allow prompt response to emerging or newly discovered outbreaks.

Alien pest control efforts should be based on the goal of maintaining biological diversity and ecological integrity of our forests, not just on production-oriented goals. All who care about the forests will benefit, whatever their views on other aspects of forest management.

Literature Cited

Anonymous. "Sugar Maples of Northeast Die, the Victims of Years of Acid Rain." *The Sunday Oregonian,* May 19, 1991. p. A22.

Abelson, P.H. 1991. Improved yields of biomass. Science 252: 1469.

Boyce, J.S. 1961. Forest Pathology, Third Edition, McGraw-Hill Book Company, Inc. New York.

Burkman, W. Q. Chavez, R. Cooke, S. Cox, S. DeLost, T. Luther, M. Mielke, M. Miller-Weeks, F. Peterson, M. Roberts, P. Seve, and D. Twardus. 1993. Northeastern Area Forest Health Report. NA–TP–03–93. United States Department of Agriculture, Forest Service. Northeastern Area State and Private Forestry, Radnor, Pa.

Burkman, William, personal communication to Faith T. Campbell.

Chastagner, G. and G. Newcombe. "An overview of poplar uses and Melampsora leaf rust pathogens in the Pacific Northwest," and "Detection of *Melampsora laricipopulina* in California." Washington State University. Poplar Leaf Rust Workshop. February 24, 1993.

Davis, M.B. 1993. Old Growth in the East: A Survey. Wild Earth Publication, Richmond, VT.

Faust, R.M. 1992. "USDA-ARS National Research Action Plan for Development of Technologies for Management and Suppression of the Gypsy Moth *Lymantria dispar.* ARII United States Department of Agriculture, Agricultural Research Service, 1992.

Goebl, M. 1987. Gypsy moth infestation on the Allegheny National Forest has direct impacts on recreationists. *In* Coping with the gypsy moth in the new frontier, S. Fosbroke and R.R. Hicks, Jr., eds., W. Va. Univ. Books, Morgantown, WV, pp. 59–64.

Grimsley, K.D. They Can't Sell the Forest for the Trees. The Washington *Post.* December 1994.

Guertin. J. Vermont Department of Travel and Tourism. Personal communication to Faith T. Campbell.

Hofacker, T.H. 1993. United States Department of Agriculture, Forest Service Staff Entomologist. Memorandum of meeting on May 28, 1993 (undated).

Jones, L. United States Department of Agriculture, Forest Service, Washington, D.C. Forest Pest Management Personal communication to F.T. Campbell.

Kendall, K.C. and S.F. Arno. 1989. Whitebark pine—an important but endangered wildlife species. *In* Proceedings—Symposium on Whitebark Pine Ecosystem: Ecology and Management of a High-Mountain Resource. Bozeman, Mt. March 29–31, 1989. Schmidt, W.C. and K.J. McDonald, Compilers. pp. 264–273.

Kliejunas, J.T., & Adams, D.H. 1981. "Phytophthora Root Rot of Port-Orford-Cedar in California" *Plant Disease.* Vol. 65, No. 5.

Kucera, D.R. 1992. New introduction, Common pine shoot beetle. Pest Alert, United States Department of Agriculture, Forest Service, Northeastern Area, NA-PR-92.

Langdon, Keith. 1991. Great Smoky Mountains National Park, in letters from Carroll Schell, to F.T. Campbell, December 1991; and March 10, 1993.

Lattin, J.D. Oregon State University Department of Entomology. Personal communications to F.T. Campbell, July 29 and October 9, 1992.

Ledig, F.T. 1992 Human Impacts on Genetic Diversity in Forest Ecosystems. Oikos 63: 87-108. Copenhagen 1992.

Lorimer, N. Staff Entomologist, Forest Pest Management, United States Department of Agriculture, Forest Service, Washington, D.C. Personal communication to F.T. Campbell.

Mazzone, H.M. and J.W. Peacock. 1985. Prospects for control of Dutch elm disease—biological considerations. J. Arboriculture 11:285–292.

McGovern, T. Operations Officer, Domestic and Emergency Operations. United States Department of Agriculture, Animal and Plant Health Inspection Service. Hyattsville, MD. Personal communication to F.T. Campbell.

Miller, Richard. United States Department of Agriculture, Forest Service, Timber Program, Washington, D.C. Personal communication to F.T. Campbell.

Millers, Imants. United States Department of Agriculture, Forest Service Entomologist, Forest Health Protection Northeastern Area State and Private Forestry. Durham, NH. Personal communication to F.T. Campbell.

New Zealand Governor General. The Forest Produce Import and Export Regulations 1989.

Ostrofsky, W.D., T. Rumpf, D. Struble, and R. Bradbury. 1988. Incidence of white pine blister rust in Maine after 70 years. Plant Disease 72: 967–970.

Pimentel, D. 1986. "Biological Invasions of Plants and Animals in Agriculture and Forestry". *In* Mooney, H.A. and J.A. Drake (eds.). Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag. New York.

Roth, L.F., H.H. Bynum, and E.E. Nelson. 1972. *Phytophthora* root rot of Port-Orford-cedar. United States Department of Agriculture, Forest Service Forest Pest Leaflet No. 131. 7 pages.

Scbmidt, W.C. 1992 Effects of White Pine Blister Rust on Western Wilderness. In Society of American Foresters 1992 Annual Meeting, Proceedings. SAF Publication 92-01.

Skilling, Darroll D. United States Department of Agriculture, Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108, personal communication to Faith Campbell.

Smith, Dr. Richard, United States Department of Agriculture, Forest Service, Forest Insect and Disease Research, Washington, D.C. Personal communications to Matthew Fogelson and to Faith T. Campbell.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 1994. Importation of Logs, Lumber, and Other Unmanufactured Wood Articles. Proposed Rule. *Federal Register* Vol. 59, No. 13 (January 20, 1994).

United States Department of Agriculture, Forest Service. 1991a. Briefing paper #FIDR–7, March 8, 1991.

United States Department of Agriculture, Forest Service. 1991b. Pest Risk Assessment of the Importation of Larch from Siberia and the Soviet Far East, Miscellaneous Publication No. 1495, September, 1991.

United States Department of Agriculture, Forest Service. 1992 Pest Risk Assessment of the Importation of *Pinus radiata* and Douglas-fir logs from New Zealand, Miscellaneous Publication No. 1508, October 1992.

United States Department of Agriculture, Forest Service. 1993. Pest Risk Assessment of the Importation of *Pinus radiata, Nothofagus dombeyi,* and *Laurelia philippiana* Logs from Chile. Miscellaneous Publication No. 1517. September 1993. 248 pages.

Virginia Department of Agriculture & Consumer Services. "Gypsy Moth: A Major Pest of Trees."

Warren, D.D. 1990. Production, prices, employment and trade in Northwest forest industries, fourth quarter 1989. United States Department of Agriculture, Forest Service Research Bulletin. PNW–RB–174. 88 pages.

Zobel, D.B., L.F. Roth, and G.M. Hawk, 1985. Ecology, Pathology, and Management of Port-Orford-Cedar (*Chamaecyparis lawsoniana*). United States Department of Agriculture Forest Service. Pacific Northwest, General Technical Report, PNW–184.

Appendix A

SUMMARY OF STATUTES (LAWS AND TREATIES) GOVERNING INTRODUCTIONS OF ALIEN SPECIES WHICH MAY ATTACK NATIVE TREE SPECIES

APHIS

International Plant Protection Convention (IPPC) (1951)
[Article 14 of the Constitution of the Food and Agriculture Organization of the United Nations] establishes international system under which inspections and quarantines are implemented to prevent dissemination of pests affecting plant resources

Federal Plant Pest Act (1957) [7 U.S.C. §§ 150aa - 150jj]
prohibits knowing importation or interstate transportation (except with a permit issued by the Secretary of Agriculture) of any plant "pest"; "pest" is defined as any living stage of invertebrates, bacteria, fungi, parasitic plants, viruses, infectious substances, etc., "which can directly or indirectly injure or cause disease or damage in any plants or parts thereof, or any processed, manufactured, or other products of plants." [emphasis added]

Organic Act (1944) [7 U.S.C. §§ 147a - 147e]
authorizes the Secretary of Agriculture, alone or in cooperation with the states or local jurisdictions, farmers' associations, governments of Western Hemisphere countries, and international organizations, to detect, eradicate, control, or retard the spread of plant "pests". (See definition of "pest" under the Federal Plant Pest Act, above.)

Plant Quarantine Act (1912) [7 U.S.C. §§ 151 - 164a, 167]
authorizes the Secretary of Agriculture to regulate imports or interstate shipments of nursery stock or other plants and plant parts and propagules when necessary to prevent introduction of injurious plant diseases and insect pests;

Agricultural Quarantine Enforcement Act (1989)
prohibits the shipping of any plant, fruit, vegetable or other matter quarantined by the Department of Agriculture via first-class mail; search warrants required to open packages

FOREST SERVICE

Forest & Rangeland Renewable Resources Research Act (1978) [16 U.S.C. § 1642]
authorizes the Secretary of Agriculture to conduct research and experiments to obtain, analyze, develop, demonstrate, and disseminate scientific information about protecting and managing forests for a multitude of purposes; § 1642(a)(3) specifies protecting vegetation, forest, and rangeland resources from insects, diseases, noxious plants, animals, air pollutants, and other agents

§ 1642(b) requires the Secretary to maintain a current comprehensive survey of the "present and prospective conditions of and requirements for renewable resources of the forests and rangelands . . . and means needed to balance the demand for and supply of these renewable resources, benefits, and uses in meeting the needs of the people of the United States. . . ."

Cooperative Forestry Assistance Act (1978) [16 U.S.C. §§ 2101, 2102, 2104]
§ 2101(a) recognizes that "efforts to prevent and control . . . insects and diseases often require coordinated action by both Federal and non-Federal land managers; . . ."

§ 2102(b) authorizes the Secretary of Agriculture to provide assistance to state foresters to develop and distribute genetically improved tree seeds and to improve management techniques aimed at increasing production of a variety of forest products, including wildlife habitat and water

§ 2104 authorizes the Secretary to protect from insects and diseases trees and wood products in use on National forests or, in cooperation with others, on other lands in the U.S.; such assistance may include surveys and determination and organization of control methods. Programs on non-federal lands can be instituted only with the consent of, and with a contribution of resources from, the owner. The Secretary may also prescribe other conditions for such cooperative efforts.

Executive Order 11987 (1977)
directs federal agencies to restrict the introduction of exotic species into natural ecosystems under their jurisdiction and to encourage states to do the same; directs the Secretaries of Interior and Agriculture to restrict the introduction into any natural system of animals or plants designated as injurious or noxious under the Lacey Act and Federal Noxious Weed Act

APPENDIX B
EXOTIC PESTS OF TREES PROBABLY INTRODUCED ON NURSERY STOCK

larch casebearer	*Coleophora laricella* (Huebner)
winter moth	*Operophtera brumata* (L.)
beech bark scale	*Cryptococcus fagisuga* Lindinger
balsam woolly adelgid	*Adelges piceae* (Ratzeburg)
chestnut blight	*Cryphonectria parasitica* (Murr.) Barr (= *Endothia parasitica* (Murr.) And. & And.)
white pine blister rust	*Cronartium ribicola* J.C. Fisch.
Port-Orford-Cedar root disease	*Phytophthora lateralis* Tucker & Milbrath
dogwood anthracnose	*Discula destructiva* Redlin

PREPARED STATEMENT OF DR. DEBORAH B. JENSEN

Mr. Chairman, Members of the Committee, my name is Deborah Jensen, and I am the Director of Conservation Science and Stewardship for The Nature Conservancy.

The Nature Conservancy is an international non-profit, land conservation organization dedicated to the preservation of biological diversity through the protection of threatened species and their ecosystems. Our membership includes more than 730,000 individuals and over 1,100 Corporate Associates.

For the past 40 years, The Nature Conservancy has preserved biological diversity through habitat conservation. In fact, many people know us as the organization that "buys land". Using a scientifically based selection process, The Nature Conservancy identifies and preserves critical habitat. Typically, the land we acquire becomes a part of our own preserve system that is managed for threatened and endangered species. However, in some cases it is transferred to government, a university or private entity dedicated to conserving the special nature of the property.

In our efforts to secure land for the protection of biodiversity, we have worked in partnership with other conservation organizations, businesses, individuals, and local, State, and Federal Government agencies. Through these partnerships we have helped protect more than 7.9 million acres of land in the United States, habitat for literally thousands of species. We have also provided technical assistance in the management of many millions of acres of land in this country and increasingly abroad.

The Nature Conservancy owns and manages 1,300 preserves nationally, with a presence in all fifty States. Although our land acquisition statistics are impressive, the science that drives our organization shows that to protect biological diversity we must do more than merely acquire habitat. We must help conserve and manage the *ecological processes* that are critical to the survival of rare plants and animals. Our work shows that one of the biggest threats to maintaining biological diversity results from the establishment and proliferation of non-indigenous invasive plants and animals. The problems created by invasive species affect not only Nature Conservancy preserves, but impact millions of acres of public land as well. The problem is so severe, that at some locations the native biological diversity is severely threatened.

There are three points I want to make in my testimony today. First, The Nature Conservancy views the current damage and the potential for damage created by invasive species as a very serious threat to biological diversity. Second, we are aggressively working on our own and in partnership with others to manage and control exotic species—and it is not cheap nor easy. Finally, there are some straightforward changes that should be made in Federal policy to help get ahead of the problem.

THE CURRENT DAMAGE AND POTENTIAL FOR DAMAGE CAUSED BY INVASIVE SPECIES IS A VERY SERIOUS THREAT TO BIOLOGICAL DIVERSITY

The problems associated with invasive species affect our preserves in all parts of the country. Dr. John Randall, Invasive Weed Specialist for The Nature Conservancy, surveyed land managers throughout our preserve system to determine the extent of invasive plant problems on our own land. Ninety-three land managers from 46 States completed the survey. Invasive plant problems were reported from all 46 States but managers from California, Florida and Hawaii reported the greatest number of invasive plant occurrences. Thirteen percent of the land managers reported that weeds were their worst problem while 59 percent ranked it among their top ten management concerns.

The land managers reported a total of 197 non-native plant species. A few species included in this category are native to North America but are now invading beyond their original ranges. The pests cited include ferns, gymnosperms and flowering plants ranging from annual, biennial and perennial herbs, floating, emergent and submersed aquatics, vines, shrubs, understory trees and canopy dominants.

The threats posed by invasive plant species can be far reaching and devastating. Invasive species can alter water tables, change fire regimes, suppress reproduction in native species and therefore change the structure of the ecological community, out-compete native species for space, change the habitat for native animal species, and provide habitat for undesirable non-native animals. For example, several preserves in the Southwestern United States have trouble with *Tamarix spp* an introduced riparian tree. Preserve managers reported that Tamarix has lowered water tables which has reduced or eliminated surface water habitats required by native plants and animals.

A recent report entitled *The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities,* produced by The Nature Conservancy's Great Lakes Program, documents that invasive fish and invertebrate species, such as the sea lamprey (*petromyzon marinus*), the alewife (*Alosa psuedoharengus*), the Eurasion river ruffe (*Gymnocephalus cernus*) and zebra mussel (*Dreissena polymorpha*) pose a significant problem to the Great Lakes ecosystem. The report states that these species have the insidious impact of causing a dramatic change in the community structure of the Great Lakes. The zebra mussel for example, is causing some shifts in phytoplankton composition (microscopic plant communities), which, in conjunction with increased grazing and predation from introduced zooplankton and higher fishes, is causing shifts in the entire lake food web.

In some cases, introduced animals and plants combine to reinforce a bad situation. In Hawaii for example, feral pigs (*Sus scrofa*) consume the fruit of introduced common guava and strawberry guava (*Psidium guajava* and *P. cattleianum*) and disperse the seeds throughout their range. The feral pigs contribute to the successful propagation of the plants by disturbing soil and providing a location for exotic plant establishment. The exotic plants exclude native vegetation from their original habitat. This interaction contributes significantly to the decline of threatened and endangered native plants.

The Conservancy is concerned about the eventual impact of invasive species in areas where they are not yet present. In Oregon, concern over the spread of leafy spurge (*Euphorbia esula*) from Montana and Idaho (where it has had a major negative impact on the quality of rangeland) has stimulated discussion and preparation for quick response when it first appears in the State. Control of invasive plants, in general, is at the top of the Oregon Chapter's Stewardship Strategic Plan.

The Nature Conservancy's problem with exotics is small when compared to the problem on other public and private land. The Forest Service has identified invasive plant problems on 6.5 million acres of land it manages. Eighty-eight National Parks have recognized invasive alien plants as a significant threat. Some reports have suggested that invasive plants are spreading at a rate of 2,000 acres per day, with a significant portion of the impact concentrated in the Intermountain West. Clearly, this "biological wildfire" impacts everyone.

II. The Nature Conservancy is Working On Its Own and in Partnership with Others to Manage Invasive Species

The Nature Conservancy is working aggressively to manage exotic species on our own land. It is extremely difficult to document the financial resources The Nature Conservancy dedicates exclusively to the management of invasive species. In most cases, management involves significant inputs of both professional and volunteer labor to physically or mechanically remove or manage exotic species. The Conservancy has used a variety of management control techniques in its arsenal of weapons. For example, at our Pine Butte Swamp Preserve in Montana we have used herbicides to control a serious and growing problem with leafy spurge (*Euphorbia esula*). Chemical control has not been effective in stopping leafy spurge from spreading and we are now exploring the release of a biocontrol agent (*Apthona nigriscutis*) to manage the problem.

Blowing Rocks Preserve, Florida—A Case Study

The efforts of our Florida Chapter to restore the Blowing Rocks Preserve are a good illustration of our institutional commitment to controlling exotic species. This case study documents a worst case example of the effort and resources required to restore an area besieged by invasive plants. Although most areas of the country do not require this level of intense involvement it is important to note that three states—California, Hawaii and Florida—are extremely vulnerable to invasions of non-natives. Since these States possess high levels of biological diversity, we are particularly active in our efforts to control invasive species in those States.

The Blowing Rocks Preserve is a 73 acre site on a barrier island in Southeast Florida with a mile of shoreline on the Atlantic Ocean and the Indian River Lagoon. It is an important nesting site for the federally endangered leatherback sea turtle (*Dermochlys coriacea*), as well as the federally threatened loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles. When The Nature Conservancy acquired the property in 1968 it was dominated by non-native plant species that threatened the native vegetation. In particular, the Australian pine (*Casuarina equisetifolia*) had severely altered the dynamic dune ecosystem at the beach. Of grave concern was the possibility that the shading of the trees lowered the beach temperature which in turn may have altered the sex ratio of incubating sea turtle eggs buried in the sand (encouraging the production of more males, which is not

desirable for maximizing reproduction). Also, the exposed roots of the pines trapped and entangled adult sea turtles when they came ashore to nest.

In 1985, The Nature Conservancy decided to take an aggressive approach to the restoration of the Blowing Rocks Preserve. From 1985–87 TNC staff, volunteers and contractors used chain saws, land clearing equipment, herbicides for stump treatments and an on-site incinerator to clear the dune area of exotics and prepare it for restoration with natives. When completed, fourteen acres of Australian pine and Brazilian pepper (*Schinus terebinthifolius*) had been cleared, leaving 35 additional acres on the western half of the island to be cleared and restored at a later date.

Because of the invasiveness of Australian pine, Brazilian pepper and other exotic species, cleared areas must quickly be revegetated to prevent re-invasion. *This is an important point to remember for any management activity which seeks to control invasive species.* In 1987, more than 50,000 native plants were installed on the cleared fourteen acre site to begin the restoration process. The site was monitored to ensure successful establishment of the native species and quick removal of any emerging exotics. This level of vigilance was and still is important, since an Australian pine can establish quickly, increasing in height by fifteen feet per year and producing over 10,000 wind-borne seeds annually.

Costs associated with the restoration from 1985–88 were $252,707, which includes clearing, removal, plantings and irrigation. These figures do not include staff time, operating expenses or the value of the volunteer labor.

In 1990, the preserve began to document the volunteer hours spent on the restoration effort. According to the Preserve's records, since 1990, 1,810 volunteers have worked 8,021 hours on the project. The hours contributed to this project by volunteers are valued at $114,700 ($14.30/hour based on information from 1,000 Points of Light Foundation). In addition, the Preserve added a volunteer coordinator and restoration coordinator in 1991 for an additional cumulative expense to date of $111,360. A quick synthesis of all this information shows that since 1985 The Conservancy has spent approximately $34,198/acre on restoration and management at the Preserve.

The Florida Chapter is committed to maintaining the biological integrity of the restored area and to continue the restoration on other parts of the Preserve. The restoration effort will extend over the next 10 years. To remove Australian pine while preserving native understory will cost between $10,000 and $20,000/acre depending on the amount of existing native vegetation. Nursery operating costs (excluding labor) are approximately $10,000/year. Rescuing and transplanting native trees from development sites or nurseries will cost between $500 and $1000/tree. These figures provide insight into the financial cost and human energy required to manage invasive non-native species and restore native species.

Aravaipa Creek, Arizona—
A Partnership to Save Threatened Species

The Nature Conservancy will be unsuccessful in its management efforts if we narrowly focus our attention inside our preserve boundaries. One glaring reality associated with exotic species is that *successful* management will depend on *coordinated* action. Since plants and animals do not respect property or political boundaries it is imperative that land managers work together toward common management goals. Efforts to manage exotic species must engage the human and financial resources of others and develop a comprehensive strategy for both public and private land.

A good example of the cooperation that is needed to tackle tough management problems can be found along Aravaipa Creek in Arizona. The Nature Conservancy owns land along the Creek which brackets a Bureau of Land Management Wilderness Area. The area provides critical habitat for seven native fish; two which are federally threatened (the loach minnow (*Tiaroga cobitis*) and spikedace (*Meda fulgida*)), and one which is a candidate for listing (the roundtailed chub (*Gila robusta*). One of the biggest threats to the fish is the aggressive, non-native red shiner (*Cyprinella lutrensis*).

In 1990, the red shiner first appeared in Aravaipa Creek. The Nature Conservancy in cooperation with the Desert Fish Recovery Team, U.S. Fish and Wildlife Service, Bureau of Land Management, Bureau of Reclamation and Arizona Fish and Game decided to initiate intensive monitoring of the Creek to determine the extent of the problem as well as to learn more about the impact of the red shiner. The Conservancy is in the third year of a 5 year cooperative agreement with BLM to provide a match of up to $10,000 annually to cover the cost of the monitoring effort. In addition, we are working with our partners to examine the feasibility of constructing physical barriers to prevent upstream movement of the red shiner.

Hawaii—A Case Example of Cooperation

No State in the Nation is more vulnerable than Hawaii to the negative impacts of harmful non-indigenous species. Hawaii's native ecosystems evolved for millions of years in isolation, and as a consequence, over 90 percent of the native plants and animals of these islands are unique life forms found nowhere else on earth. Today, the combination of Hawaii's mild climate and the State's modern role as a hub of Pacific trade exposes the islands to a flood of new, harmful pests. Each year, an average of twenty new invertebrate species become established in the islands. Of these, an average of five are pests and at least one per year proves to be of major economic significance. Since 1985, for example, four new insect pests of sugarcane have been established: of these, the lesser cornstalk borer alone has cost $9 million to control (this does not include the cost of reduced yields).

The magnitude of the threat posed by the continual introduction of non-indigenous species into Hawaii has led to widespread agreement among scientists, farmers, environmental groups and government agencies that stemming the influx of new pests is among the State's highest priorities.

As a manager of Hawaiian rain forests and other habitats for endangered species in the islands, The Nature Conservancy of Hawaii (TNCH) has been deeply involved in efforts to control harmful non-indigenous species, including feral pigs and noxious weeds. In 1992, the Conservancy teamed up with the Natural Resources Defense Council (NRDC) to identify a process to address this frightening problem. Together, we produced a report entitled, "The Alien Pest Species Invasion in Hawaii: Background Study and Recommendations for Interagency Planning" (The Executive Summary is attached).

The report found that one of the biggest obstacles to more effective prevention and control of pest species is the lack of coordination and the fragmentation of current management programs. The analysis found that over the past 100 years, twenty State and Federal agency programs have arisen *ad hoc* to address the specific concerns of their particular audience. This has resulted in a set of programs that are generally effective within each individual jurisdiction, but together leave many gaps for pest entry and establishment.

All twenty of the State and Federal agencies involved in non-indigenous species prevention and control in Hawaii agree that a multi-agency planning effort must be undertaken to move the existing system toward a cohesive and comprehensive pest prevention and control system. Toward that end the Hawaii Department of Agriculture has initiated a multi-agency planning process to prepare an Action Plan which will set out specific improvements in the critical areas of pre-entry prevention systems, border inspection, rapid response to new invasions, and control of most destructive established pests. We feel this should be followed by a public education campaign and a Phase II plan for coordinated agency training and research. The Nature Conservancy intends to keep working with our agency colleagues to help them improve their capacity to control the non-native species.

III. Changes Should Be Made in Federal Policy to Address the Problem

The Office of Technology Assessment Report, "Harmful Non-indigenous Species in the United States" did an excellent job of suggesting policy options to address the problems associated with invasive species. We support many of the suggestions that were made in the OTA Report and would like to underscore a few of the recommendations.

To counteract the problems created by exotics, we as a nation must work together to do three things. First, we must promulgate proactive policies which will *prevent the release* of new invasive species. Second, we must *require better inter-agency. State and Federal cooperation and coordination* to resolve jurisdictional issues which leave current management efforts fragmented and inadequate. Finally, we must devote more resources to research and management efforts which address existing problems.

A. *Prevent the Release of New, Harmful Invasive Species*

The smartest and most cost-effective action to address the problems associated with invasive species is to prevent their introduction. The old saying, "an ounce of prevention is worth a pound of cure" is absolutely accurate when it comes to invasive plants and animals. Imagine the money that would be saved if leafy spurge had never entered the country, a plant which according to a recent study produced by North Dakota State University will cost the States of North Dakota, Montana and Wyoming $144 million annually by 1995.

Current regulatory efforts have focused on preventing the release of animals and plants which pose a threat to agriculture, while ignoring those non-indigenous species which impact natural areas. We would like to see Congress and the Administra-

tion take action to prevent the release of invasive species which will impact not only agriculture but biological diversity and natural areas as well.

Specifically, we would like to recommend the following:

1. *Amend the Federal Noxious Weed Act to include the listing of weeds which are deleterious to natural areas.*

The Nature Conservancy, supports current efforts to amend the Federal Noxious Weed Act. The draft amendment will expand the definition of noxious weeds to include invasive plants which affect natural areas, as well as plants which are foreign in origin and currently not present in the United States, but have the potential to be invasive. Expanding the list will help control the importation and interstate movement of invasive species. The changes would establish a technical committee which will assist the Secretary of Agriculture in developing the list of Federal noxious weeds. In addition, it will provide the Secretary with emergency authority to act quickly in response to the import or release of a potentially threatening non-indigenous plant.

2. *Congress should encourage the adoption of a model State law which will provide a framework for controlling non-indigenous species.*

States have almost complete control over the release of non-indigenous fish and wildlife. In some cases, States have comprehensive laws which set-up a thorough review process prior to release of a non-indigenous species. In other States, the review process is weak. We propose that a comprehensive model law be developed for voluntary adoption by the States to provide a framework for the proper review of non-indigenous species prior to approval for release. The model law should establish criteria for excluding already established but non-threatening non-indigenous species, criteria for a list of prohibited species and finally a framework for reviewing species before approval is given for release. The model should also provide a framework for the quick eradication of new releases that prove to be invasive.

The Federal Government should provide economic incentives to the States to encourage adoption of the model law. For example, Federal funds should be available to enable States to review existing laws and develop changes which will bring it into conformity with the model law. Also, Federal dollars for fish and wildlife activities should be contingent on the adoption of the model law. Finally, States which have already established comprehensive State laws should be exempted from adopting the model as a requirement to receive Federal funds.

3. *Implement Executive Order 119867—May 24. 1977—Pertaining to exotic organisms.*

President Carter Issued an Executive Order in 1977 which directs the Executive Agencies to "restrict the introduction of exotic species into natural ecosystems on lands and waters which they own, lease, or hold for purposes of administration. . ." It encourages other levels of government and private individuals to do the same. It also directs the Executive Agencies to restrict the importation of exotic species. The Executive Order was a good step towards establishing a national policy on non-indigenous invasive species. Unfortunately, the Executive Order has never been implemented. We would like to see the current Administration reaffirm this Executive Order and require the Federal agencies to implement strategies to prevent the introduction of harmful non-indigenous species.

B. *Encourage Inter-Agency Coordination and Cooperation at the State and Federal Level*

4. *Congress must direct Federal agencies to work cooperatively to develop a national strategy to control invasive species.*

In 1990, amendments to the Federal Noxious Weed Act included in the Farm Bill directed the Federal land management agencies to control invasive species on Federal land. In response, several of the land management agencies have developed management programs. Also, a number of dedicated agency representatives have tried to spark interagency dialogue and cooperation on the topic of invasive species. Despite these efforts, the agencies still lack the focus and commitment of resources required to do the job. It is time that Congress require the agencies to devote adequate time and attention to the control of invasive species. We would like to see the establishment of a high-level committee, with representation from each of the 21 agencies mentioned in the OTA Report, convened to establish a coordinated response to invasive species.

5. *Federal agencies should work creatively with State agencies to solve jurisdictional problems. Particular attention should be paid to preventing the introduction of non-indigenous species in Hawaii.*

In order to significantly improve our country's management of harmful non-indigenous species, State and Federal agencies must coordinate their actions and develop innovative solutions. The need for cooperation is particularly acute in Hawaii, where alien species pose the number one threat to the survival of the State's federally listed endangered species.

For example, a multi-agency task force in Hawaii (U.S. Fish and Wildlife, U.S. Postal Service and the Hawaii Department of Agriculture) has been working for the past year to implement Senator Akaka's Alien Species Prevention and Control Act—specifically, the provisions of that Act that call for a trial inspection program for Hawaii-bound mail parcels (pests arriving through the mail account for 20 percent of Hawaii's pest invasion problem). Although everyone involved is committed to solving the problem, jurisdictional complications are impeding progress. The Federal and State agencies should be encouraged to identify jurisdictional problems, define solutions and work creatively to enact those solutions in an expedited manner.

C. *Appropriate More Money for Research into the Control of Existing Problems and Management Activities on Federal Lands.*

6. *Devote more resources for research to control non-agricultural invasive species.*

Current research to control exotic species is primarily devoted to species which have an agricultural impact. We would like to see more attention directed to the development of management tools which address invasions in natural ecosystems. Research on a variety of control technologies should be encouraged, such as biocontrol or the identification of changes in land use practices which can prevent or manage invasions by exotic species.

However, non-native biological control agents must be rigorously reviewed to ensure that the agent itself does not become a problem. Existing review standards are inconsistent, particularly in relationship to insect releases to control other insects. The review process should include a thorough assessment of the organism's impact on natural areas. Any biological control effort should be a part of the *solution* not a part of the *problem* .

7. *Provide more resources to the land management agencies to tackle invasive species problems on their own land.*

The Federal land management agencies have been woefully underfunded in their efforts to control exotic species. For example, the U.S. Forest Service has identified weed problems on 6.5 million acres of land. The Administration budget recommendation in fiscal year 1995 for Noxious Weed Control under the Forest Service's Range Management Program calls for $2.82 million, a modest increase of $483,000 over last year. This money will enable the Forest Service to tackle weed management on only 35,500 acres of land (1/18th of the need).

The inadequate funding at the Forest Service is an example of the problem as it exists across the Federal land management agencies. The National Park Service, The Bureau of Land Management and other agencies all suffer from inadequate funding. In addition, field personnel need more training in the identification and management of invasive species.

Our experience shows that invasions of some non-indigenous plants start slowly but without proper attention escalate quickly into significant problems. Therefore, by not aggressively tackling land management problems now, the Federal lands are open to explosive, more serious problems in the future.

The Nature Conservancy views exotic species as a serious threat to the integrity of biological diversity in the United States. We feel there is a need to develop a national policy to stop the introduction and spread of invasive species. In addition, we feel the States and Federal agencies must cooperate to solve jurisdictional problems and coordinate management efforts. Finally, more financial and human resources must be dedicated to the research and development of control technologies as well as to manage existing problems on public lands.

The Nature Conservancy is committed to work with Congress, public agencies and private interests to help solve the problem of invasive species. We are grateful that the Committee is taking the time to explore policy improvements. Thank you for inviting me, as a representative of The Nature Conservancy, to testify on this important topic.

* * * * *

THE ALIEN PEST SPECIES INVASION IN HAWAII [1]

BACKGROUND STUDY AND RECOMMENDATIONS FOR INTERAGENCY PLANNING

EXECUTIVE SUMMARY

The silent invasion of Hawaii by pest species—weeds, disease organisms, predators, insects, etc.—has far-reaching consequences for the State's people, economy and natural environment. Pest species already established in Hawaii are responsible for large losses of agricultural and horticultural crops. These pests limit the shipment of local produce to mainland markets, damage native forests, streams and watersheds, compete with native flora and fauna, and carry diseases that affect native species, agricultural crops, livestock and humans. The magnitude of the threat posed by the continual introduction of alien species into the State has led to widespread agreement among scientists, farmers, environmental groups and government agencies that stopping the influx of new pests is essential to Hawaii's future well-being.

This report describes and assesses the current systems used in Hawaii to prevent the introduction of unwanted alien species and to respond to those pests that succeed in entering the State. It is intended to help focus coordinated, multiagency planning to solve the complex alien pest problem.

Hawaii has been actively involved in alien pest prevention and control for a century. Today, at least 20 State, Federal and private organizations and a number of volunteer groups dedicate a major part of their resources to this area.

Prevention

In general, Federal agencies in Hawaii are concerned with preventing the introduction of noxious pests into the U.S. from foreign sources and preventing pests established in Hawaii from reaching the U.S mainland. Their work is guided by Federal laws and rules that have evolved with a focus on protecting large-scale mainland agriculture and enforcing international trade agreements. The U.S Customs Service, U.S. Fish and Wildlife Service, U.S. Department of Agriculture's Animal and Plant Health Inspection Service, and the U.S. Department of Defense's Military Customs Inspection Program are the Federal agencies most involved in prevention activities.

Compared to Federal agencies, State agencies have a larger responsibility for the prevention of noxious pest introductions that may be damaging to Hawaii. State agencies assume most of the task of preventing U.S.-mainland pests from reaching Hawaii. Because of Hawaii's tropical environment and unique natural history, the State is vulnerable to far more foreign pests than the typical mainland State. Therefore, State agencies rely on Federal colleagues to call them in on foreign pest introductions that pose a threat to Hawaii but may not be prohibited in the U.S. The Hawaii Department of Agriculture carries out virtually all of the State's prevention programs. Several volunteer task forces and private educational programs have also been initiated to bolster public awareness and promote improved prevention systems.

Control

The control of established or newly escaped pests in Hawaii is primarily the responsibility of State government, although Federal agencies (U.S. Fish and Wildlife Service, National Park Service and U.S. Department of Agriculture) carry out pest control operations on Federal lands, enforce endangered species laws, and carry out research to improve control methods. The lead State agencies involved in control are the Department of Agriculture and the Department of Land and Natural Resources. Private organizations including the Hawaii Sugar Planters' Association, Bishop Museum, The Nature Conservancy of Hawaii, and Hawaii and Maui Humane Societies are involved in aspects of alien species control as well. While there is some coordination among these agencies and groups, most focus only on agriculture or human health, or native ecosystem pest problems.

Problems

Despite the efforts of these organizations, unwanted alien species are entering Hawaii at an alarming and increasing rate. Since the 1970s, an average of 20 new alien invertebrates (insects, molluscs, etc.) per year were recorded in Hawaii. This

[1] Prepared by The Nature Conservancy of Hawaii Natural Resources Defense Council—July 1992

is an increase from 16 per year between 1937 and 1960. (By comparison, scientists estimate that before man's arrival, a new invertebrate became established in Hawaii on a rough average of only once every 10,000 years. The current rate of invasion, then, is about 200,000 times more rapid than the natural rate.)

Approximately one-half of the immigrant invertebrates established between 1981 and 1991 are regarded as economic pests. One in twenty—or about one per year—is a "serious" economic pest. Since 1985, four new insect pests of sugarcane have become established; of these, the lesser cornstalk borer alone has already cost sugar planters an estimated $9 million.

While information on how these pests are entering the State is incomplete, inspectors estimate that most are entering via airline passenger flights, first-class mail and cargo. The mainland U.S. is the leading source of pests, followed closely by southeast Asia, tropical America and the southwest Pacific.

Meanwhile a number of pest species already established in Hawaii are spreading. Although concerted efforts have succeeded in limiting the spread of selected crop diseases or forest pests, most interisland pest traffic is largely unchecked.

The chief areas of concern identified through interviews, a workshop with agency staff and other research are as follows:

1. A large proportion of the total passengers, cargo and other traffic entering Hawaii is currently uninspected, including materials known to be significant sources of new alien species;
2. The effectiveness of inspections is hampered by inadequate sampling strategies;
3. Penalties for illegal introductions are inadequate;
4. Federal quarantine programs do not adequately address Hawaii's special vulnerability to foreign pests;
5. The current process for determining which species are to be prohibited from or allowed into the State does not adequately address the full range of alien pest threats, and does not balance the interests of alien pest control against horticultural or other plant and animal trades;
6. Response to new infestations is frequently delayed by jurisdictional or organizational problems, allowing pests to become established and, in some cases, to spread beyond control;
7. Interisland spread of pests is a major, largely unregulated problem;
8. Control efforts are not taking full advantage of available technologies; and
9. Agency mandates sometimes call for maintenance of potentially destructive alien species as resources for sport hunting, crops, aesthetic resources or other values.

Next Steps

A multiagency planning effort is urgently needed to develop a cohesive and comprehensive pest prevention and control system. Over the past 100 years, agency programs have arisen *ad hoc* to address specific concerns of a particular audience. The result today is a set of programs which are generally effective within their own jurisdictions but which, together, leave many gaps and leaks for pest entry and establishment. A multiagency plan must invest especially in prevention activities because of their lower cost and greater chances of success when compared to long-term control operations for an established pest.

Effective systems will also require strong public support and participation, essentially making pest prevention and control a part of everyday island life. Although public understanding of threats like snakes and other dangerous pests has increased through recent media exposure, the average citizen remains unaware of the magnitude of the problem. On-going public support, however, depends on a compelling and practical strategy for long-term prevention and control.

A two-phased planning process is suggested, to begin in the summer of 1992. Phase 1 should result in:

a) Pre-entry prevention strategy;
b) Port-of-entry sampling and inspection strategy;
c) Statute, policy and rules review to clarify conflicts/gaps and determine a coordinated approach for resolving them;
d) Rapid response strategy; and
c) Statewide control strategies for selected, established pests.

Phase 2 planning is intended to draw on the products of Phase 1 to produce:

a) Cohesive training strategy;
b) Coordinated data systems;
c) Coordinated research strategy; and

d) Expanded public awareness campaign.

For both political and technical reasons, this process will be a major undertaking. To succeed, it should be guided by a simple, clear policy statement identifying the standard of excellence Hawaii aspires to in this field (e.g., "Hawaii will develop a pest prevention and control system that is the most effective in the world", or ". . . that reduces the influx of new pest species into the State to 10 percent of present levels by the year 2000"). Because of its long history and broad involvement in this area, the Hawaii Department of Agriculture is the most appropriate agency to lead such a planning effort.

PREPARED STATEMENT OF PHYLLIS N. WINDLE

Unlike you, we at OTA virtually *never* receive letters from constituents. But last October, Lawrence Sperandio, of Verona, Missouri, read a newspaper account of OTA's report and wrote to me:

> "I am a 65 year old disabled veteran who has given up on controlling the worst plant ever imported into the United States, the multiflora rose. Forty years ago, a neighbor allowed the Missouri Conservation Commission to plant a ½ mile fence row of multiflora on his farm ½ mile from my farm. This neighbor allowed the fence to grow uncontrolled and birds spread the rose seed over miles across two counties. I have spent thousands of dollars and more than that many hours without slowing its spread. The neighbor responsible is dead. . . . I am physically and financially broke after . . . battling this pest that leaves land in an unproductive jungle state. . . . My farm is greatly depreciated by this terrible plant and my elderly wife will have no inheritance in her declining years and my heirs may be saddled with damages assessed by the State of Missouri. I plead for your assistance."

There is very little that I can do to help Mr. Sperandio. You, however, have many more options. Today, we shall describe how we got to a place where this farmer finds his Government derelict. Also, we shall discuss ways to remedy the situation.

Thank you, Mr. Chairman. I am Dr. Phyllis Windle from the Office of Technology Assessment. With me today is Elizabeth Chornesky. I directed the OTA study that we will discuss today; Dr. Chornesky was the senior analyst on that study.

Mr. Sperandio's case is not unusual. I can guarantee that harmful non-indigenous species (NIS) affect the constituents of every Member of this Committee. If your State is agricultural, probably 50–75 percent of your weeds are non-indigenous and your constituents suffered some of the estimated $3.6 to $5.4 billion in crop losses and herbicide costs per year nationwide. If your State contains a wildlife refuge, a National Park, or other protected areas, it is almost certain that it has problems with harmful NIS and is short of resources to manage them successfully. If your constituents own pets, travel overseas, fish, hunt, garden, or engage in interstate commerce the issues we discuss affect every one of them directly.

WHERE WE ARE TODAY: THE STATUS AND IMPACTS OF HARMFUL NON-INDIGENOUS SPECIES

Over one-half of the trees and shrubs on the Capitol grounds are not indigenous to the United States. They, like almost all our crops, many sport fish, and numerous biological control agents, provide substantial economic, aesthetic, and other benefits.

Harmful NIS, however, cause substantial damage. In OTA's judgment, these impacts are likely to climb. Troublesome species already in the United States are rarely eliminated while new ones are constantly added. As a result, the combined number of foreign NIS is steadily and swiftly growing. In the process, problems multiply like compound interest. One expert calls this "an explosion in slow motion".

At least 4,500 NIS of foreign origin have established free-living populations in the United States, a much larger number than was present 100 years ago. Approximately 15 percent, or several hundred species, trigger severe harm.

The threat of new introductions is ongoing. Just since 1980, some 200 foreign species were first introduced or detected here. At least 59 of these are already, or are expected to be, harmful.

Most organisms arrive with human help, often as unintended contaminants of commodities, packing materials, shipping containers, or ships' ballast. Others were intentionally imported as crops, ornamental plants, livestock, pets or aquaculture species—and later escaped confinement. A number of NIS were introduced as seemingly desirable species for soil conservation, fishing and hunting, or biological con-

trol but later caused unexpected harm. And some enter illegally—via first class mail or in travellers' baggage.

Because our actions are responsible for the majority of introductions, we have many opportunities to make improvements. However, continuing changes in patterns of international travel and trade may make this job more difficult.

Almost every part of the Nation faces at least one highly damaging NIS—like the zebra mussel, gypsy moth, or yellow star thistle. Now, NIS account for 25 percent of U.S. fish; 17 percent are U.S. species moved outside their natural ranges. In a number of States, non-indigenous plants account for 10 percent, 20 percent, or 30 percent of all plants. In Hawaii, at least one-half the State's wild plants and animals are non-indigenous.

Certainly harmful non-indigenous species are in our backyards—Asian clams are abundant in the Potomac River. European starlings and English sparrows are daily companions—and responsible for declines of eastern bluebirds. Five non-indigenous vines are toppling trees and eliminating wildflowers in Rock Creek Park and along the C&O Canal and George Washington Parkway. A Maryland suburban nursery sells several varieties of a wetland weed that, between 1987 and 1991, Minnesota spent $500,000 to control.

Economic Losses

Unfortunately, Minnesota's expenditures are just the tip of an iceberg. From 1906–1991, just 79 NIS caused documented cumulative losses of $97 billion, mostly in control costs and direct losses of marketable goods. For example,

- In 1990, leafy spurge caused direct losses of livestock production of $110 million over 1.5 million acres in the northern Great Plains.
- The European gypsy moth caused $764 million in forest and other losses in 1981, its all-time high.
- Removal of salt cedar along the lower Colorado River and restoration of indigenous vegetation is estimated at $45 to $450 million.

Our $97 billion total includes only 14 percent of the species known to be harmful and excludes one of the most costly groups—agricultural weeds. Thus, it likely represents only a fraction of the total costs because so many species and kinds of primary and secondary impacts are uncounted. For example, economic impacts on industries other than agriculture, on human health, and on protection of natural areas are seldom quantified.

However, we can conservatively estimate that harmful NIS annually cause losses of hundreds of million of dollars for agriculture, fisheries, forest, and rangelands. Losses can reach several billion dollars or more in high-impact years. A worst case scenario for 15 high-impact species adds another $134 billion in potential future economic losses.

Environmental Impacts

> Botany professor Clifford Smith drives the 12 miles to work at the University of Hawaii. His trip from one side of the island to the other takes him past what Hawaii's visitors see: a lush green paradise. But what Dr. Smith sees are plants virtually all from elsewhere. Only four native species grow along that 12-mile stretch, and only one of those is moderately common.

Like so many seemingly Hawaiian plants, populations of NIS can spread like wildfire in new habitats where their former competitors, predators, pathogens, and parasites no longer keep them in check. Asian clams are believed to have arrived on the West Coast before 1924. As of 1986, these clams could have come from 6 of the 14 states that the Committee represents. We each helped pay the estimated $1 billion in losses Asian clams caused the power industry in the early 1980s.

At their worst, harmful NIS cause declines of indigenous species and contribute to extinctions. The most destructive species also can transform entire ecosystems. Some, like chestnut blight in eastern forests, radically shift species composition. Other, like the zebra mussel, drastically modify an ecosystem's basic features.

The popular press and environmentalists frequently stress the role of harmful NIS in species extinctions but—except for islands—much of the supporting evidence is anecdotal or equivocal. Over-emphasizing extinctions tends to divert attention from other significant and unambiguous environmental damage. Biological communities can be radically and permanently altered without extinctions occurring. The United States can experience a significant decline in the abundance, diversity, and aesthetic value of its indigenous species, also without extinctions. Both kinds of changes are common now:

- Two non-indigenous grasses now comprise 80 percent of the plant cover in parts of Hawaii Volcanoes National Park—grasses that have increased the frequency of brush fires and offset normal ecological processes.
- Mosquitofish have been associated with localized declines in at least 15 indigenous fish in desert rivers and springs.
- The Australian melaleuca tree is rapidly replacing the Florida Everglades sawgrass marshes, forests and other natural habitat with single species stands.
- In the Flathead River-Lake ecosystem, the recent introduction of opossum shrimp started a series of reactions. Eventually, the areas's fish predators—including eagles, otters, coyotes, and bears—were driven away.

The introduction of NIS is, however, closely correlated with the disappearance of indigenous species in Hawaii and other islands. Biological control agents in Hawaii have been implicated in the loss of 15 indigenous moth species. In Guam, the brown tree snake is believed to have caused extinctions of five species or subspecies of birds and declines of numerous others. If it reaches Hawaii, its effects would probably be similar.

As of 1991, the U.S. Fish and Wildlife Service considered NIS a contributing factor in listing 160 species as threatened and endangered, or, on average, about 25 percent of all listings. Harmful NIS were considered the major cause for listing 41 of these species, 23 of which are from Hawaii or Puerto Rico. Even indigenous species on the U.S. mainland can be pushed dangerously low when harmful NIS combine with other environmental stresses such as pollution or habitat destruction. For example, the combination of extensive water projects and the introduction of species better adapted to such altered habitats is considered the major cause of drops in California's indigenous fish, 76 percent of which are declining, threatened, endangered, or already extinct.

THE ADEQUACY OF CURRENT POLICY

> Mr. Sperandio blames the Missouri Conservation Commission and State law for his predicament. He could more rightly cite the Federal Government. The U.S. Department of Agriculture (USDA) introduced multiflora rose and encouraged its use. Thus, there is more than enough responsibility to go around.

It is commonly accepted that the Federal Government has no national policy on non-indigenous species. President Carter issued a far-reaching executive order on NIS in 1977. In practice, it has been ignored by most Federal agencies. Moreover, the U.S. Fish and Wildlife Service (FWS) has yet to implement the order in regulations although specifically directed to do so.

Instead, the Nation has responded to harmful NIS with a largely uncoordinated patchwork of laws, regulations, policies, and programs. Many only address NIS peripherally, whereas others address the more narrowly drawn problems of the past. In general, Federal efforts only partially match the problems at hand.

Exclusion and Enforcement

We may never be able to fully predict the risks of new introductions and, thus, screen organisms properly. However, past intentional and accidental introductions of fish and wildlife have had about equal chances of turning out badly. This suggests a history of poor decision-making. For some species—keeping them out is the best strategy. For others, control is easier than interception at ports of entry. So aiming for a standard of "zero entry" is unrealistic and undesirable, especially if exclusion comes at the expense of control.

The Federal Government currently plays a much larger role in preventing the entry of agricultural pests than in excluding other potentially harmful NIS. In fiscal year 1992, USDA's Animal and Plant Health Inspection Service (APHIS) budgeted at least $100 million for agricultural quarantine and port inspection. This compares to $3 million for port inspections of fish and wildlife requested by FWS. Likewise, the Federal Government devotes significant resources to managing and preventing interstate movement of agricultural pests but little to pests of natural areas or fish and wildlife.

Without better goal setting, data gathering, and evaluations, we cannot tell whether pre-introduction screening, monitoring, quarantine, and enforcement are adequate. However, OTA's long list of newly introduced or detected species provides indirect evidence that the system fails with some regularity. These examples provide additional proof:

- In 1988, grass seed contaminated with an Argentinian weed was distributed by popular retailers such as K-Mart and Walmart. Over 58,000 pounds were sold in at least five States before the seeds' 1989 recall.
- The Asian Amur maple has become common in woods and fields surrounding SCS's Lincoln, Missouri plant testing center, from where it apparently escaped.
- In 1985, the Asian tiger mosquito, a vector of several serious viral diseases, was discovered in Houston, apparently imported in containerized shipments of used tires. The Centers for Disease Control and Prevention rejected a research and control plan in 1987 and, in 1988, issued regulations requiring that such imports be free of mosquitoes. According to one expert, attempts to ensure compliance are minimal. As of 1991, mosquitoes had spread to 22 States. Recently, eastern equine encephalitis, a disease with a 30 percent mortality rate in humans, was isolated from a Florida tire dump 9 miles from Disney World.

Lapses come about for a wide variety of reasons. Certain categories of harmful NIS are not restricted from entry at all. Many species' entry is prohibited only after they have become established or caused damage in the United States. Adding new organisms to lists of prohibited or regulated species is often difficult and time consuming. Also, delays in preventing entry sometimes occur when new pathways emerge that have no regulatory history, e.g., proposed timber imports from Siberia and the import of used tires.

No coordinated efforts prevent the spread of large categories of harmful NIS within the country. In fact, at least five plants on the Federal Noxious Weed Act were legally sold in interstate commerce in 1990. Weeds, as a group, receive little attention from APHIS, despite clear authorization in the Federal Noxious Weed Act. Weed control program throughout Federal agencies are generally small and underfunded.

Insufficient authority or impetus exists for Federal agencies to impose emergency quarantines on pests that do not damage agriculture. Neither USDA's Soil Conservation Service (SCS) nor its Agricultural Research Service systematically evaluates plants' invasiveness before release for soil conservation or horticulture. According to one expert, at least 7 of the 22 cultivars released by SCS between 1980 and 1990 could become weeds of natural areas.

Adequacy of enforcement is difficult to assess because solid information is missing. However, a recent FWS advisory commission noted that the agency's enforcement division was understaffed and underfunded. Also, it lacked clear priorities, adequate staff supervision, and sufficient technical expertise. Amendments to the Lacey Act in 1981 allowed FWS to enforce State-restricted injurious fish and wildlife. No such interceptions were listed among the agency's 1990 accomplishments, though, suggesting that enforcement is not a high priority. Likewise, compliance with Federal and State laws limiting interstate distribution of federally or State-listed noxious weeds is, in effect, largely voluntary.

Agency Jurisdiction and Interagency Efforts

Federal laws leave both obvious and subtle gaps that most States do not fill adequately. Significant gaps exist for non-indigenous fish and wildlife and their diseases, weeds, vectors of human diseases, and NIS in natural areas. Many gaps apply to genetically engineered organisms as well; they and NIS are commonly regulated under the same laws.

At least 20 Federal agencies research, restrict, regulate, control, or sponsor NIS, with USDA and the Department of Interior playing the largest roles. Also, Federal agencies manage about 30 percent of the Nation's lands, many with grim NIS problems. Yet Federal management policies are often inconsistent within and among agencies and implementation inadequate. Conflict between agencies is rare, at least in part because legislative and regulatory gaps prevent much jurisdictional overlap.

The 1990 Non-indigenous Aquatic Nuisance Prevention and Control Act created an interagency task force to deal with harmful aquatic NIS. The Task Force is co-chaired by FWS and the National Oceanic and Atmospheric Administration and draws additional members from five other Federal agencies.

The Act set out a number of assignments, many with completion dates that have been considerably delayed. Several factors account for this delay. Little funding was initially appropriated for new responsibilities or staff. In the absence of clear national policy, Task Force members spent a substantial amount of time reaching consensus goals. Finally, administrative details—such as a charter and a memorandum of understanding—slowed its progress. On the other hand, FWS' participation in the Task Force has stimulated a much-needed internal review of agency policies. And the Task Force's "Intentional Introductions Policy Review" aims to improve risk assessments for proposed introductions.

The 1990 law and the Task Force could have a significant role in preventing the unintentional entry and dissemination of harmful aquatic species. For example, the law provides for Federal grants to States with approved aquatic nuisance management plans—grants that have been unfunded since authorization. Also, the Lacey Act's limited controls on aquatic imports and interstate movement could be supplemented as the Task Force develops its "Aquatic Nuisance Species Program." Regulations on import and quarantine of aquatic and wetland weeds could fill gaps in the Federal Noxious Weed Act, especially those related to weeds of natural areas.

However, regulations are not underway or planned in these areas. The Task Force chose to interpret the Act as not addressing aquatic NIS that escape from aquaculture facilities—excluding significant concerns. Also, States worried that the draft program lacked mechanisms to disperse funds for emergency control. OTA concluded that "the rocky start of the [Task Force] makes its future potential uncertain."

Federal and State agencies cooperate on many programs related to agricultural pests, but their policies can also conflict, e.g., when different agencies manage adjacent lands. Federal law preempts State law in some specific cases, more often regarding agriculture than fish and wildlife. Conflicts between States also occur, often without forums for resolving disputes. A widely cited example is North Dakota's experimental release of the zander, a new sportfish. Both Minnesota and Canada objected to the release, citing ecological and disease risks.

State laws are relatively complete for agricultural pests, but spotty for invertebrate and plant pests of nonagricultural areas. The State role is most critical for the import and release of fish and wildlife, where there is less Federal presence. States' fish and wildlife laws use a variety of approaches and vary from lax to exacting. Many such laws are weak and inadequately implemented. Others, however, present exemplary approaches that could serve as important models, e.g.:

- The way Tennessee funds fish and wildlife management from either NIS permit fees or its general fund.
- The burden of proof required by Georgia before import and release of NIS.
- Utah's legal and regulatory thoroughness for fish and wildlife.
- The host of educational material prepared by Ohio Sea Grant and the State Department of Natural Resources on the zebra mussel.
- Maine's control of baitfish imports, upheld in a key 1986 Supreme Court decision.

Harmful NIS have hit Hawaii and Florida particularly hard because of their distinctive geography, climate, history, and economies. Cooperative efforts have sprung up in both places. Increasingly, State and Federal agencies, nongovernmental organizations, agricultural interests, and universities see harmful NIS as a unifying threat and public education as one important tool to alleviate it.

POTENTIAL AND PROSPECTIVE FEDERAL ACTIONS

Expanding environmental education is just one step Congress could take to improve U.S. management of harmful NIS. Others might include amendments to the Lacey Act and the Federal Noxious Weed Act to fill gaps and ensure broad interpretation. Federal policy cannot succeed without State help. Model State laws or national minimum standards are two possible ways to ensure more adequate authority for States.

In addition, Congress could require stricter screening for invasiveness in federally funded efforts using NIS. And Congress could provide adequate authority for emergency treatment of early NIS infestations—often the only hope for staying ahead of enlarging pest populations.

Also, Congress might direct additional funds specifically to weed management on public lands and to resource management generally in National Parks and other protected areas. However, assigning new responsibilities without money does not work, as the experience of the Aquatic Nuisance Species Task Force has shown. Thus, Congress might consider further the questions of liability and accountability. Congress could, for example, expand the application of entrance or user fees to risk analysis for new introductions. Additional fees and/or higher fines could decrease incentives to import or spread harmful NIS and fund the control necessitated by those that cause harm.

In some cases, change is underway. In Congress, Representative Studds expects to introduce legislation on fish and wildlife in the House Merchant Marine and Fisheries Committee. Senator Dorgan and Representative Rose are drafting separate amendments to the Federal Noxious Weed Act. And we are aware of your amendment to the Crime Bill for consolidating enforcement of biological crimes.

Meanwhile, this initial OTA study has spawned additional research on biological pest control at OTA. The Bureau of Land Management and the Forest Service are organizing an interagency working group to tackle weed problems on public lands. They, like other Federal agencies, are responding to requirements in the 1990 Farm Bill. APHIS is making policy and program changes that respond to OTA's concerns. For instance, APHIS' pilot project under the Government Performance and Results Act will set objectives and standards for pest exclusion for the first time. The Soil Conservation Service is incorporating OTA's critique in its 5-year resource appraisal required by the 1977 Soil and Water Resources Conservation Act. And the Aquatic Nuisance Species Task Force continues its work.

While these initial steps are important and gratifying, OTA identified some other larger and longer-term issues that only Congress can resolve. These are questions of national values. Certainly better management of harmful NIS will save money. It will also help conserve the resources that we are committed by law and treaty to protect. But there is another, less tangible benefit.

Picture the acres of vast wetlands along the Atlantic coast, the salmon fisheries of the Pacific Northwest, and the vast canyon lands of the West. Consider the unique dunes around Lake Michigan and our only tropical lands in Hawaii and Puerto Rico. Imagine the miles of wheat, corn, rice, Douglas fir, and loblolly pine that stretch from border to border.

Our country possesses a rich, one-of-a-kind inheritance of plants, animals, and microbes. Failing to limit harmful NIS threatens industries based on beneficial ones and obscures our Nation's uniqueness. In the process, we risk squandering our country's natural and agricultural heritage. Ultimately, only Congress can enact a vision to protect our country's biological legacy. And only Congress can determine what level of risk we are willing to accept.

PREPARED STATEMENT OF ROBERT DAVISON

Thank you for the opportunity to provide the Committee with a summary of the efforts, policies, and concerns of the Department of the Interior regarding the introduction of non-indigenous species.

The global transfer of non-indigenous organisms is one of the most pervasive and perhaps least recognized effects of humans on the ecosystems of the world. In order for this issue to be addressed effectively, we must start from an understanding that any introduced species that survives the transfer will interact with the community it colonizes.

Human-mediated transport has largely removed the natural barriers to invasion that are partly responsible for the evolution of distinct ecosystems. This new found mobility of species has had profound environmental and economic consequences.

As documented in the Office of Technology Assessment (OTA) report, *Harmful Non-Indigenous Species in the United States,* many non-indigenous species have been transferred unintentionally (ballast water and other means), while others were intentionally introduced to meet human purposes (landscaping, biological control, recreational fishing, food production, and the aquarium trade).

It is important to realize that once a species is introduced into an open ecosystem, it is extremely difficult (often virtually impossible) to remove it—introduction, like extinction, is forever. Thus, the most important strategy is to prevent the introduction and consequent spread of harmful non-indigenous species.

Non-indigenous species are neither inherently "good" nor "bad", and some species produce both good and bad ecological and economic consequences, depending on location and society's perceptions. Of the thousands of non-indigenous species in the United States, many provide enormous benefits, especially in agriculture. However, 15 percent (675) have been identified as having severe, unwanted economic costs. In the last century, just 79 of these 675 species cost the American public an estimated $97 billion in damage to natural resources and industrial productivity. Costs of just 15 existing non-indigenous species in the United States are expected to exceed $100 billion over the next 50 years. For example, the zebra mussel is expected to cost about $400 million per year in the Great Lakes Basin alone. The sea lamprey has cost millions of dollars in losses to recreational and commercial fisheries and millions of dollars in control programs since its entry into the Great Lakes in the 1920s. These figures imply a heavy burden on the American public and institutions, and do not take into account future introductions.

Some areas have experienced particularly high numbers of introductions. Hawaii, for example, has more than 3,000 non-indigenous species, many of which have been cited as factors in the high rate of extinction in the archipelago's largely endemic biota. In the Great Lakes, at least 139 non-indigenous aquatic organisms have be-

come established since the 1800s, more than one-third of them during the past 30 years. Several of these species, including the sea lamprey and alewife, contributed to massive alterations in the Great Lakes fish community.

As the country's principal land management and natural resource agency, the Department of Interior manages many programs dealing with non-indigenous species.

The National Biological Survey (NBS) has established a research and monitoring program to: 1) determine the effects of non-indigenous species on native flora and fauna; 2) develop methods which can be used to prevent the introduction of potentially nuisance species into the Nation's ecosystems, 3) develop environmentally safe measures to control established nuisance species, and 4) monitor the distribution and potential spread of non-indigenous species in North America. Activities range from evaluating the effectiveness of fences in controlling feral animals in the Hawaii Volcanoes National Park to determining the response of black bears to gypsy moth induced mortality of trees. NBS has recently joined an interagency effort to develop a coordinated approach to contain invasive, non-indigenous weeds. In partnership with other Federal and State agencies, NBS also conducts research on chemical and biological control of sea lampreys in the Great Lakes.

The Department is also coordinating with other Federal, State, Tribal, and local governments to implement the Non-indigenous Aquatic Nuisance Prevention and Control Act (Act) of 1990 (P.L. 101–646) to address non-indigenous aquatic species at the national level. The Aquatic Nuisance Species Task Force (ANS Task Force) established by the Act has proven to be an excellent mechanism for interagency coordination. As co-chairs of the ANS Task Force, the Director of the U.S. Fish and Wildlife Service and the Under Secretary for Oceans and Atmosphere, Department of Commerce, are jointly responsible for implementing most provisions of the Act in consultation and cooperation with the other members of the Task Force. The Service provides staff support to the Task Force and along with NBS, chairs a number of Task Force Committees.

The cornerstone of the Act and the major responsibility of the ANS Task Force is the development of the Aquatic Nuisance Species Program (ANS Program). The Service and NBS took a leadership role in development of the program, which has undergone public review and will be sent to Congress this spring following Administration clearance. Implementation of this comprehensive program will build on existing non-indigenous activities and be a cooperative effort among Federal agencies, States, Tribes, local governments, nongovernmental entities, and other countries.

The primary objectives of the ANS Program are to: prevent the introduction and dispersal of aquatic nuisance species; monitor, control and study aquatic nuisance species; and disseminate related information. Supporting elements of the program include research, technical assistance, education, and a zebra mussel demonstration program.

The zebra mussel infestation was the catalyst for establishing the Act and much of our non-indigenous species effort has remained focussed on the zebra mussel within the Department of Interior. The Service, NBS, National Park Service (NPS) and the Bureau of Reclamation (BR) are all conducting and coordinating zebra mussel related activities.

The Service and the National Park Service, in cooperation with State and local governments, have developed a "Zebra Mussel Response Program" to prevent the spread of the zebra mussel into the St. Croix National Scenic River. The St. Croix River, a tributary of the Mississippi River, supports several species of endangered mussels. Multi-agency efforts include information/education, boat inspections and access management, watercraft decontamination, and monitoring.

The Service and the Bureau of Reclamation are working together to "head them off at the pass." The Service conducted a study to determine the feasibility of stopping or slowing the spread of zebra mussels west of the Continental Divide where they may impact large reservoirs, dams, irrigation systems, etc. An interagency meeting was sponsored by the Service and BR in February 1994 to develop interagency strategies to address this problem. Activities which will be initiated by the Service in fiscal year 1994 include preparation of information/education programs for the general public, performing risk assessments on Service facilities that may be at risk, and assisting western States in developing containment and prevention strategies and programs. Additionally, the Service and the Bureau of Reclamation are developing a Memorandum of Understanding to facilitate cooperative efforts to prevent, monitor and control zebra mussels and other non-indigenous aquatic nuisance species on BR and Service lands.

Research is an important support element of the ANS Program and NBS has conducted considerable research to support management of zebra mussel related problems. The NBS Great Lakes Center has conducted studies on the biology and life history of zebra mussel and their effects on native biological communities and habi-

tats. The NBS LaCrosse Center has conducted research on environmentally safe strategies for controlling zebra mussels and evaluating the effects of zebra mussels on riverine biota and aquatic food chains. The NBS Northern Prairie and Patuxent Centers have cooperated on biological control of zebra mussel by waterfowl.

The Control element of the ANS Program outlines a risk assessment and management process to ensure prompt and systematic evaluation of proposed control measures. In response to a control proposal submitted by the Great Lakes Fishery Commission, the ANS Task Force developed a control program to slow or stop the spread of the ruffe (a small fish) from Lake Superior. Proposed ruffe control measures include range reduction by physical and chemical means, ballast water management through voluntary guidelines, population investigation, surveillance, predator evaluation, and education. In addition to serving as chair of the ANS Task Force Ruffe Control Committee, the Service is conducting population investigation studies, surveillance programs and information/education programs. In support of the ruffe control program, the NBS Great Lakes Center is conducting studies on the biology and life history of the ruffe and the Lacrosse Center is conducting research on strategies for chemical control of ruffe. The ruffe control program has been developed cooperatively by member agencies of the ANS Task Force and affected State, Tribal and local resource agencies.

The Act also directed the ANS Task Force to develop a Research Protocol to ensure that "research activities carried out under the Act do not result in the introduction of aquatic nuisance species to waters of the U.S." The Research Protocol Committee, chaired by NBS, developed a protocol that consists of a risk assessment and a set of guidelines outlining preventative containment and confinement procedures that must be followed if research is conducted under the Act. As the Nation's biological research agency, the NBS is providing leadership for inter-agency efforts to identify research priorities, develop collaborative and complementary research and monitoring programs, and provide information transfer. Largely in response to the zebra mussel invasion, about three-quarters of NBS's fiscal year 1994 budget on non-indigenous species ($3.5 million) is directed at aquatic nuisance species, especially the zebra mussel. NBS is currently preparing a Five-Year Plan (fiscal year 1995–fiscal year 1999) for Congress on the prevention, containment and control of non-indigenous aquatic nuisance species.

Monitoring of non-indigenous species is necessary to detect new introductions, track their dispersal, and document their effects on aquatic ecosystems. The ANS Task Force has established a Detection and Monitoring Committee to coordinate monitoring activities and develop an information system to collect and distribute this information. This committee, chaired by the NBS, has proposed to use a Geographic Information System (GIS) developed by the NBS for documenting the occurrence and distribution of non-indigenous aquatic species and their rate of spread. Service regional biologists track the dispersal of the zebra mussel to provide an early warning to affected industries, Federal, State and local officials. This information is incorporated into the GIS and maps displaying zebra mussel dispersal are developed and distributed on a periodic basis. The GIS currently contains more than 10,000 reports of non-indigenous aquatic species. The NBS Environmental Management Technical Center is also conducting monitoring and public education in the Upper Mississippi River Basin.

Section 1102 of the Act requires the completion of three studies on the introduction of aquatic nuisance species. One of these studies, the Biological Study was to determine whether aquatic nuisance species threaten the ecological characteristics and economic uses of U.S. waters (other than the Great Lakes). The ANS Task Force will address this study on a case study basis, examining specific geographic areas where aquatic nuisance species have historically been or may potentially be a problem. In fiscal year 93, the Service initiated two case studies to examine the ecological and economic effects of biological invasions in the San Francisco Bay and Delta Region and the State of Florida. The case study in Florida is being conducted by the NBS Gainesville Center. A case study of the Chesapeake Bay area will also be funded by the Service and is anticipated to begin later this year.

Section 1209 of the Act required the ANS Task Force to develop and undertake a program to control the Brown Tree Snake in Guam and other areas where the species has become established outside of its native range. The ANS Task Force established a Brown Tree Snake Control Committee comprised of representatives of appropriate Federal, State, and Territorial agencies. The objectives of this committee are to ensure coordination of activities and develop a Brown Tree Snake Control Program. A draft Brown Tree Snake Control Program has been developed. NBS's Patuxent Center is currently conducting research on brown tree snake populations on the Pacific islands, evaluating the design and feasibility of snake barriers and

traps, creation of snake-free areas, methods of detection and biological and chemical control methods.

Many of the programs discussed to this point have dealt with unintentional introductions. The ANS Task Force, established under has also undertaken an effort to identify and evaluate approaches for reducing the risk of adverse consequences associated with the intentional introductions of aquatic organisms. A report to Congress on the findings, conclusions and recommendations of that review has undergone extensive public scrutiny and will be submitted to Congress this spring, following Administration clearance.

Additional non-native species research activities being conducted by NBS include cooperative efforts by the Alaska and Madison Centers on a study of the role of non-native birds as competitors and vectors of pathogens on native Hawaiian forest birds. NBS also has a major effort on the inventory, monitoring and taxonomy of non-native and special status plants on Federal lands including developing techniques to control invasive exotic weeds.

The Service has ongoing efforts on National Wildlife Refuges to control non-native nuisance species in order to protect and maintain populations of native species.

The Department of the Interior is committed to carrying out its responsibilities under the Non-indigenous Aquatic Nuisance Prevention and Control Act and other authorities, and working jointly with the other Federal, State and conservation agencies to ensure that we protect our fish and wildlife resources from all non-indigenous nuisance species and doing everything within our authority to prevent the introduction of new harmful non-indigenous nuisance species. Some of the best Federal policy strategies for the future to address non-indigenous species are contained within the Act. The development and establishment of the ANS Program will provide the Federal agencies with a comprehensive framework with which to address non-indigenous aquatic species. Implementation of this program will require a steady commitment and a continuing coordinated effort by the Federal agencies with responsible for addressing these problems. In addition, the ANS Program could serve as a model for developing a comprehensive national strategy to address the introduction of all harmful non-indigenous species.

The completion of the Intentional Introductions Policy Review and the ANS Program, as well as the progress on the other studies required by the Act, demonstrate the effectiveness of ANS Task Force as a forum for cooperation and reflect a shared commitment and dedication among Federal agencies in addressing non-indigenous species problem.

This concludes my prepared statement. I would be pleased to answer any questions you might have.

PREPARED STATEMENT OF KATHARINE W. KIMBALL

Mr. Chairman and Members of the Committee:

I am Katharine Kimball, Deputy Assistant Secretary for Oceans and Atmosphere, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. I am also Co-Chair of the interagency Aquatic Nuisance Species Task Force (Task Force) created by the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 (Act). I appreciate the opportunity to discuss the risks presented by both unintentional and intentional introductions of non-indigenous species. Recognizing that the Committee has heard from a number of witnesses touching on freshwater introductions, I will emphasize saltwater issues in my testimony.

The Act was designed to mitigate the overall problem of aquatic nuisance species. It established an interagency Task Force to achieve this end. The Task Force is co-chaired by NOAA and the U.S. Fish and Wildlife Service (FWS) and includes representatives from the Coast Guard, the Environmental Protection Agency (EPA), the Army Corps of Engineers, the Animal and Plant Health Inspection Service of the Department of Agriculture, and the Department of State. In addition, there are eight ex officio members appointed to represent non-Federal entities.

Historically the problems associated with introductions of non-indigenous species were the result of inadequate knowledge and review. Very little attention was given to the various pathways that unintentionally resulted in movement of species. A shrinking world has meant increasing mobility, more rapid transportation, and increased demand for foreign products. As we all have become less isolated, the probability that non-indigenous species will be introduced into new ecosystems has risen. In the case of intentional introductions, past introductions have taken place without adequate review of the potential risks involved.

The Non-indigenous Aquatic Nuisance Prevention and Control Act provided a series of tasks to be carried out with the goal of preventing and mitigating the prob-

lems associated with introductions of non-indigenous species. The Task Force has made an effort to fulfill its responsibilities under the Act despite having less funding available than authorized.

Much of the impetus for the Act was the result of concern over the catastrophic introduction of zebra mussels into the Great Lakes, and a major portion of the Federal effort has focussed on addressing this problem.

In the marine environment, we are unable to point to major catastrophes caused by species introductions as catastrophic as the introduction of the zebra mussel into the Great Lakes. There are two reasons for this. First, as the Office of Technology (OTA) report pointed out, some ecosystems are particularly vulnerable to species invasions. Marine environments may be relatively less vulnerable to catastrophic invasions. Second, we may simply be unaware of major marine introductions because we still know less about marine ecosystems than terrestrial or freshwater ecosystems.

Nevertheless, there are examples of species introductions into marine environments that have had negative impacts. In April 1993, NOAA sponsored an international workshop on Non-indigenous Estuarine and Marine Organisms. Participants in the Workshop concluded that while we were not aware of a catastrophic introduction of zebra mussels that had occurred in the marine environment, such an occurrence is almost inevitable in the future. Participants also discussed past problems associated with introductions.

Whenever they occur, there are a number of potential risks associated with both unintentional and intentional introductions. An introduced species may cause the decline of native species in a number of different ways. Indigenous species may be affected by direct predation, competition for key habitat or other resources, or hybridization. Serious pathogens or parasites also may accompany a species when it is introduced.

Although there has been a tendency to focus on fish and shellfish introductions, species that can be nuisances may include plants, single celled organisms, invertebrates, pathogens, and parasites.

Off the east coast the introduced green alga, *Codium fragile*, was first considered to be a nuisance in the area of Long Island in the early 1970s. The species has now spread as far south as South Carolina, and there is concern that if it spreads farther, it could affect coral reefs by blocking the sunlight on which they are dependent. The saltmarsh cordgrass, *Spartina alterniflora*, is used for shoreline stabilization on the east coast. However, it has had negative impacts after being introduced to the west coast. It aggressively invades intertidal oyster habitat and can reduce oyster productivity. Spartina traps sediments and can transform low mudflats to higher islands and may adversely affect Dungeness crab larvae that rely on mud flat habitat.

San Francisco Bay and the delta region feeding into the bay provide examples of two other types of organisms that can have negative impacts. The Asian clam *Potamocorbula amurensis* has colonized the bay and has been found in densities of more than 20,000 per square meter. Several introduced copepods have displaced the native copepod *Eurytemora affinis* which is a preferred prey species for a number of larval fish. Alterations in prey base may have affected striped bass and other fish production in the delta area.

Even if a species itself is not a nuisance, it may introduce pathogens and parasites. Although of uncertain origin, one only needs to consider the impact of MSX and dermocystidium on oyster production in the Chesapeake Bay to see the potential problem. Pathogens have had a serious impact on a number of economically important species. In addition to oysters and clams, other pathogens have been transferred with salmon and shrimp. The State of Hawaii has among the most stringent screening requirements for diseases. This occurred because the introduced shrimp virus IHHNV was responsible for major losses in the aquaculture industry. Even introductions that have, on the whole, been beneficial have been accompanied by parasites. A significant portion of U.S. oyster production is dependent on the Japanese oyster *Crassostrea gigas* that was introduced to the west coast. A number of species were accidentally introduced with the oyster. One, the Manila clam, has itself become a significant commercial species. However, two parasites—the Japanese oyster drill and the oyster flatworm became established as a result of the oyster introduction.

In Hawaii, a marine fish introduction may have led to the decline of a native species. Near Oahu, the introduced Marquesan mullet has displaced the native mullet for which a valuable fishery exists.

The United States is not only a recipient of aquatic nuisance species. There are examples of species from our waters that have impacted other ecosystems. The Black Sea has been invaded by comb jellies from our waters. Comb jellies prey on

phytoplankton, and there is concern that phytoplankton levels are so reduced that the prey base for native fish species has been adversely affected. Although a cause-and-effect relationship has not been established, there has been a marked reduction in fisheries production since comb jellies were initially introduced.

Australia is extremely concerned that the toxic dinoflagellates responsible for red tide blooms in the United States may be introduced in ballast water. The introduction of a viral disease with hatchery salmon from the United States has had an adverse impact on the native masou salmon in Japan.

As indicated earlier, the problem of zebra mussel infestation galvanized demand for Federal legislation. Under the Act, a number of Federal agencies have provided funding for research on methods to control zebra mussels. To prevent further ballast water introductions into the Great Lakes, the Act mandated that the Coast Guard issue regulations on the management of ballast water in the Great Lakes. Those regulations became effective on May 10, 1993. As part of the National Ballast Water Control Program (Section 1102 of the Act), the Task Force is mandated to conduct Ballast Water Exchange, Biological and Shipping Studies.

The Ballast Exchange Study has been initiated and will assess the environmental effects of ballast water exchange and identify areas, if any, where exchange does not pose a threat. The project has been initiated through a grant from EPA's Office of Research and Development and will be conducted at and administered through NOAA's Great Lakes Environmental Research Laboratory. Additional funds from NOAA and the U.S. Fish and Wildlife Service will allow completion of the study by June 1995. The study will assess the environmental impacts of the release of salt water in the Great Lakes and other freshwater ports and the survival potential of open ocean organisms in coastal zones. It also will identify areas where ballast water may be discharged safely.

The Biological Study mandated by the Act is currently being conducted to determine whether non-indigenous species threaten the ecological characteristics and economic uses of U.S. waters other than the Great Lakes. The study was initiated with FWS funds and is currently proceeding on a case study basis. Additional funds from NOAA and EPA will be used to complete the case studies. A study on the environmental impacts of non-indigenous aquatic species in Florida, begun in July 1993 by FWS, will be completed this year. A similar study on the fresh, brackish, and marine waters of the San Francisco Bay-Delta region began in September 1993 and will be completed this year. A case study of the Chesapeake Bay is currently being developed.

The Shipping Study was conducted by the Coast Guard to determine the need for controls on vessels entering U.S. waters to prevent the introduction and establishment of aquatic nuisance species. The study has been completed and will be transmitted to the Congress after Administration clearance.

Although a significant portion of our effort has been directed toward zebra mussels and ballast water in the Great Lakes, the Task Force has taken steps to address the issue of non-indigenous species introductions in other areas. As I indicated earlier, NOAA sponsored a workshop on Non-indigenous Estuarine and Marine Organisms last April. Since that meeting, interest has been expressed in holding a second workshop exclusively devoted to ballast water issues. We have approached the Government of Australia, which has been involved extensively in this field for a number of years, regarding dual sponsorship of such a workshop.

The central component of the Act is development of a comprehensive Aquatic Nuisance Species Program. The proposed program has undergone public review and revision and will be sent to the Congress after administration clearance. The Program will build on existing non-indigenous activities and involve Federal agencies, States, Tribes, local governments, and non-governmental entities. The Program consists of the following elements: prevention, monitoring and detection, control, research, technical assistance, education, and the Zebra Mussel Demonstration Program.

The Task Force's Risk Identification and Management Committee is developing a pathway identification risk assessment process to prevent unintentional introductions of non-indigenous species. The committee has met and is modifying a process developed by the Department of Agriculture' s Animal and Plant Health Inspection Service for evaluating non-indigenous plant pests to develop the risk assessment portion of this element.

Detection and monitoring of non-indigenous species will be accomplished through coordination of existing activities and field studies by the Monitoring Committee and through a data repository and information management system currently operating at the National Biological Survey's Fisheries Research Center in Gainesville, Florida.

A control risk assessment and management process outlined in the Program will address control of aquatic nuisance species. The Task Force has already imple-

mented this process in the case of the unintentional introduction of the ruffe, a European perch species, via ballast water into Lake Superior. The Task Force decided that control of this species was warranted and set up a Ruffe Control Committee. A proposed control program has been developed, and when the environmental assessment document has been completed, it will be released for public review.

The Act mandated development of a Research Protocol so that research activities funded under the Act do not themselves result in introductions of aquatic nuisance species. Last year, the Task Force approved a final protocol developed by the Research Protocol Committee. The protocol establishes a decision tree to assess risks and contains guidelines outlining preventive containment and confinement procedures that must be followed on any research conducted under the Act.

Section 1204 of the Act provides that individual States may submit State Aquatic Nuisance Management Plans to the Task Force for approval. States with approved Management Plans are eligible for a Federal grant program for projects to prevent and control aquatic nuisance species. The first plan was submitted by the State of New York. The Task Force approved the plan on March 1, 1994.

Although the focus of the Act was on unintentional introductions of aquatic nuisance species, Section 1207 requires the Task Force to submit a report to Congress containing recommendations for reducing the risks associated with intentional introduction of non-indigenous aquatic species. The report is finished and has been submitted to the full Task Force for approval. We expect to submit the report to Congress this Spring following Administration approval.

In addition to co-chairing the Task Force and those activities mentioned above, NOAA has been involved with a number of other non-indigenous species activities. Our involvement dates back to the early 1970s when the agency was created. At that time, the National Marine Fisheries Service (NMFS) established a shellfish disease research program. In addition to shellfish pathogen and parasite research, NMFS monitors the presence of pathogens in imported seafood through a Memorandum of Understanding with the Food and Drug Administration. NMFS also has provided technical advice to the State of Hawaii and serves on the State panel that reviews proposed introductions of aquatic species.

NOAA's National Sea Grant College Program administers aquatic nuisance species research grants. Sea Grant researchers address a variety of aquatic nuisance species issues, including the brown mussel on the Gulf of Mexico coast, ballast water studies in the Chesapeake Bay, sea lamprey and watermilfoil (aquatic plant) in the Great Lakes, and Spartina marshgrass in the Pacific Northwest. The Sea Grant Zebra Mussel program is concentrating on the effects of zebra. mussels on infrastructure and the environment, and on the development and evaluation of potential control methods. The Great Lakes Environmental Research Laboratory has set up a Non-indigenous Species Coordinated Research Program. Under this program, researchers have set up a monitoring program in Saginaw Bay in Lake Huron. They monitored the Bay both prior to and following infestation by zebra mussels. They are also conducting a series of life history studies.

The National Sea Grant College Program also provides education and technical assistance through its State Sea Grant Offices and Marine Advisory Service program. The Zebra Mussel Information Clearinghouse is a project of New York Sea Grant. The Clearinghouse publishes *Dreissena polymorpha* Information Review which summarizes research, meetings, legislation, and sightings of zebra mussels as means of encouraging and facilitating communication among interested parties. It provides copies of papers on zebra mussels published in scientific journals. This project has created a closely integrated network of researchers and extension agents who are developing control methods and communicating the results to local communities, affected industries, and management agencies including some inland states without their own Sea Grant Programs.

NOAA's National Estuarine and Research Reserve System has monitoring programs to establish baseline parameters on species presence in a variety of coastal areas. The sites are well integrated with State agencies and nearby academic communities. They can be used as a framework from which to initiate a long-term monitoring program on the occurrence and spread of non-indigenous species. Beginning in 1995, NERRS will have as a research priority the study of alterations of habitat utilization by coastal biota and restoration of coastal habitats that have been impacted by non-indigenous species.

The waters of the United States are a resource of immeasurable environmental, economic and aesthetic value. Although the Task Force started slowly, we have picked up the pace and are well on the way to establishing a comprehensive program to deal with the risks presented by non-indigenous species. Further recommendations are likely to emerge as a result of some of the studies that I have mentioned. Although it is not possible to prevent all species introductions—indeed

there have been some beneficial introductions, we should be able to reduce the risk of non-indigenous aquatic species with the potential to become nuisance species from becoming established.

Mr. Chairman, thank you for the opportunity to testify on this important issue. I will be pleased to answer any questions that you may have.

PREPARED STATEMENT OF B. GLENN LEE

Mr. Chairman and Members of the Committee, I am pleased to be here today to discuss with you the report by the Office of Technology Assessment (OTA) on Harmful Non-Indigenous Species in the United States. The efforts of the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) to prevent and control the spread of non-indigenous species (NIS) were reviewed in the OTA report.

USDA appreciates the tremendous effort that OTA put into creating such a comprehensive document. We understand the problems associated with NIS, and believe the report generated valuable insight into approaches for handling such difficult issues. As the report indicates, the negative effects of certain non-indigenous species have created economic losses in the billions of dollars. For example, the annual crop losses attributable to non-indigenous weeds is approximately $2 billion to $3 billion.

The OTA report concludes that a dynamic national agenda is needed to effectively address NIS in the United States. We agree with this conclusion and assert that USDA should be a major participant in this effort. APHIS, in particular, has significant experience and expertise in monitoring and evaluating the dangers of NIS, and in developing Federal/State cooperative regulatory programs for exclusion, control, and eradication of non-indigenous plant and animal diseases and pests. We have also worked with successful models for Federal, State, and industry voluntary programs to address these issues.

We have traditionally been charged with protecting agriculture in the United States from plant and animal pests and diseases, and noxious weeds. Generally, we concentrate our efforts on excluding exotic agricultural diseases and pests. Where feasible and cost-effective, we institute control or eradication activities such as those involving the screwworm, Mediterranean fruit fly, and boll weevil. On those occasions where exotic agricultural diseases and pests become established in the United States, APHIS may implement programs which prevent their further spread.

The OTA report identified a number of modified or new services that APHIS or another agency could provide for effective protection against harmful non-indigenous species. For example, the OTA report recommends that APHIS, as U.S. Agriculture's "first line of defense," more closely examine any proposed introduction (importation, interstate movement, or release into the environment) into the United States of a non-indigenous organism. APHIS believes it must supplement its current regulations to better meet the problems posed by invading non-indigenous organisms. The Agency is currently developing comprehensive regulations governing the introduction of non-indigenous organisms that may be plant pests. The regulations would provide a means of screening proposed introductions of non-indigenous organisms to determine potential plant pest risks. Of course, this would also entail an evaluation of environmental effects of authorizing the introduction of non-indigenous organisms as required under the National Environmental Policy Act (NEPA).

Another area that has been highlighted as a problem is noxious weeds. The report accurately states that APHIS currently regulates only interstate transport of noxious weeds if a quarantine is in place, and imposes a quarantine only if a control or eradication program exists. This practice is in accordance with the legislative history of the Federal Noxious Weed Act of 1974. APHIS has drafted new legislation that would consolidate and streamline the plant quarantine laws. This draft legislation would expand the Agency's role in regulating noxious weeds and would eliminate the requirement that the Agency initiate a control and eradication program and impose a quarantine prior to regulating interstate movement of noxious weeds. APHIS has also developed a comprehensive weed policy that will form the basis for broader management and control of weeds.

The Agency has also drafted legislation to consolidate and streamline the animal quarantine laws and allow for regulation of any material that can carry an animal pest or the agent or vectors of disease. Both legislative proposals are currently under Administration clearance.

OTA contends that "responsibility for studying, regulating, and controlling harmful NIS in non-agricultural areas such as parks and protected areas is a large enough problem that it needs to be assigned explicitly to some agency or institution." APHIS is a member of the Aquatic Nuisance Species Task Force, which is,

in part, developing risk assessment and risk management processes to evaluate environmental pests as well as pests causing more traditional economic damage. This task force will address NIS in non-agricultural areas as well. APHIS recognizes that its services can benefit non-agricultural areas. Likewise, APHIS' programs to control certain types of noxious weeds and vertebrate pests are protecting native ecosystems. APHIS is willing to work with Congress and other agencies in any way to determine the necessary resources, and/or priorities to address issues related to non-indigenous species.

In addressing the problems associated with non-indigenous species in Hawaii, OTA suggested that a greater Federal role may be warranted. OTA also recognized, however, that increased Federal involvement in domestic arrival inspections in Hawaii would require a change in APHIS' mandate, as well as increased staffing and other resources for the Agency. As a means of further protecting Hawaii, APHIS is currently working on implementing a program for inspection of first-class mail from the mainland to Hawaii which was authorized by the Alien Species Prevention and Enforcement Act of 1992. APHIS has had several meetings with the U.S. Department of Interior, the U.S. Postal Service, and the Hawaii Department of Agriculture in Honolulu and in Washington. APHIS is working to develop appropriate Memorandums of Understanding with the Department of Interior, and other agencies.

The OTA also noted that "APHIS does not consistently prevent repeated importation of pest species that are already established here. New, different strains of some species potentially may be imported, worsen effects, and spread into areas where the pest is not yet well-established." We acknowledge this potential type of danger; protecting against these types of pests is not inconsistent with the Agency's mission. However, we do not currently attempt to prevent introduction of all pest species that are already established here for a number of reasons. While we have authority to regulate introductions of plant pests, regardless of whether or not they are already present in the United States, our exclusion decisions must comply with existing international trade agreements, and must be in accord with science-based risk information.

We believe that improvements can be made, and are being made, to current programs to measure effectiveness and to analyze risk. OTA acknowledges that complete exclusion of pests from the United States by APHIS probably is infeasible. However, OTA also asserts that the overall success of APHIS' efforts to exclude pests is difficult to evaluate, in part because the Agency lacks performance measures to determine the effectiveness of port inspection activities and programs in pest exclusion. In recognition of the potential value of improved performance measures, we have initiated a pilot project to develop goals and indicators to measure the results of the exclusion function, including the Agricultural Quarantine Inspection (AQI) program. This project is to be one of the pilot projects of the Government Performance and Results Act of 1993. The goal of the project is to enable APHIS to better articulate desired program outcomes and to measure whether those desired outcomes are being achieved.

We are also responding to the identified need for improvement in the U.S. system of monitoring agricultural diseases and pests. We already conduct the National Animal Health Monitoring System, which provides scientifically sound and statistically valid data regarding the incidence, trends, and economic impact of food animal diseases and pathogens. Our Cooperative Agricultural Pest Survey (CAPS) provides for the timely collection, storage, processing, and distribution of significant plant pest and disease information for Federal agencies and State departments of agriculture.

The OTA notes that biological control agents that are not microbes, are exempt from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and fall under APHIS' jurisdiction. OTA also notes that APHIS has not yet promulgated regulations specifically for such agents; instead APHIS requires researchers and producers to follow procedures and permitting requirements developed for plant pests under existing authority. APHIS is reviewing biocontrol organisms that are non-indigenous on the basis of their potential for plant pest risk. Many biocontrol organisms are exotic species being introduced for the first time, often to control their pest hosts which are also non-indigenous. Good biocontrol organisms should have limited potential to cause harm to unintended targets. We intend to have permitting requirements commensurate with the level of risk. We are participating in an interagency group reviewing biological control organisms. As mentioned earlier, we are now developing regulations to cover the introduction, interstate movement, and release into the environment of non-indigenous organisms.

The OTA points out several perceived weaknesses with APHIS' risk analysis process. In recent years, APHIS has sought to improve and standardize its risk assessment procedures; we will continue to work to modify these procedures, and will continue well into the future. With respect to APHIS' requirement for demonstrated

risks before preventing imports, APHIS, as a matter of principle does not require regulations unless a justification can be demonstrated.

Although we applaud and value the OTA study, there are several items that we believe should be brought to your attention. The study did not cover organisms such as those causing animal diseases, including those transmissible from animals to humans. In response, APHIS would like to make clear that control and exclusion of these organisms have constituted major technical, scientific, and regulatory successes in this century. APHIS' Veterinary Services programs that produced these successes could offer working models, expertise, and many hard-earned lessons on quarantine, inspection, and testing procedures. APHIS reviewers believe that the OTA study may obscure, rather than clarify, key issues related to the assessment and management of risks associated with genetically engineered organisms (GEOs). The OTA study fails to make sufficiently clear that if transgenic plants are to be considered a special case of NIS, it is because they are derived from customary agricultural cultivars that are themselves descended from NIS. The act of genetic modification with modern molecular techniques does not by itself render an organism "non-indigenous."

When developing and implementing programs to protect agriculture and our natural resources, funding and resources are usually big questions. We currently assess user fees to fund many exclusion activities. If an expanded role is envisioned for APHIS, alternatives for funding, including user fees should be considered.

Public education is an avenue toward developing awareness of the economic loss and/or environmental harm that can result if prohibited plants, injurious animals, pests, and diseases enter our country, or parts of our country. For example, our public information program in Hawaii has increased the awareness that it is illegal to send fresh fruits and vegetables to the mainland, resulting in a decrease in the number of illegal items being sent to the mainland since the program began in 1989.

The Department has been and will continue to be closely involved with activities to protect against harmful non-indigenous species. For example, the U.S. Forest Service and APHIS worked together to resolve issues related to the importation of unmanufactured wood products and continue to work together in the control of the Asian Gypsy Moth. As noted earlier, APHIS is a member of the Aquatic Nuisance Species Task Force and we work with the Department of Interior and the Department of Commerce, the co-chairs of the Task Force. Other members of the Task Force are the Environmental Protection Agency, U.S. Coast Guard, Department of State, and the U.S. Army Corps of Engineers. Also, our Animal Damage Control unit of APHIS cooperates with the Department of Defense, the Government of Guam, and the Department of Interior to control the brown tree snake in Guam. These are but a few examples. We are willing to cooperate with these and other agencies in developing a comprehensive strategy to impede the movement and invasion of harmful non-indigenous species into our country.

We appreciate the Committee's interest and look forward to meeting the challenges identified in the OTA report. We will be happy to answer any questions.

PREPARED STATEMENT OF WILLIAM McCLEESE

Thank you for the opportunity to offer our views on non-indigenous plant and animal species in our Nation's forest and rangeland ecosystems. I am accompanied by Dr. Jerry Sesco, Deputy Chief for Research.

Background

Non-indigenous plant and animal species are a serious threat to the integrity of our forest and rangeland ecosystems. The chestnut blight, white pine blister rust, Dutch elm disease, and leafy spurge are the more commonly known introduced pests in the United States. They are examples of exotic pests that completely changed our forest and rangeland ecosystems by eliminating significant species such as the American Chestnut, Eastern White Pine, and American Elm over much of their original ranges and in our cities. Not only did they change our forests, but they resulted in serious economic losses as well. The costs of trying to control these pests, the cost of research, the loss of forest products and wildlife habitat, and the damage to local economies has been in the billions of dollars.

There have been over 200 forest insect pests, 20 major diseases, and over 100 exotic plant species introduced into this country over the past two centuries. The rate of introduction is increasing because of increasing tourism and commerce among Nations. To counter this continuing increase in the rate of introduction, we must expand our application of our regulatory authorities and develop a greater capacity to respond to new introductions. We must also develop improved methods for con-

trolling those exotic pests that have become established and threaten our native ecosystems.

In addition to economic losses, these exotic pests severely affect the forest ecosystem. Wildlife that is dependent upon a declining native species for food or habitat is adversely affected. Species composition and structure of the forest change because species that are immune to the exotic pest replace the susceptible species. Additional forest changes occur because these immune species are often less adapted to these sites, and, therefore, are more susceptible to native diseases, insect pests, and stresses caused by normal changes in weather patterns. In some areas, the Forest Service has identified this changing of species composition and the invasion of exotic plants as the greatest threat to our forest and rangeland ecosystems, including our wilderness areas.

Our rangelands are being severely impacted, and it is estimated these exotic plants have infested over 14 million acres of western Federal lands, where they are rapidly displacing the native vegetation. Some of the most invasive species include several species of thistles and knapweeds, leafy spurge, dalmatian toadflax, and St. Johnswort. Without their natural checks and balances, these exotic species can freely invade healthy ecosystems, regardless of disturbance, and once established, create monocultures that severely reduce species diversity and can become impossible to control with current methods. The results are severely degraded ecosystems that no longer provide quality wildlife habitat, forage for both wild and domestic ungulates, or quality recreational experiences. Finally, some threatened and endangered species plant species are at considerable risk since they cannot compete with these exotic plants.

The Office of Technology Assessment, in their report "Non-Indigenous Pests," estimates that economic losses due to invading exotic plants are several billion dollars annually. A 1993 study completed by the University of North Dakota found that the invasion of leafy spurge alone had a direct economic impact on grazing and wildlands of $87 million.

In Hawaii, exotic plants, such as gorse, banana poka, fireweed, and strawberry guava are invading and severely damaging native forest and rangeland ecosystems. They are also preventing the reclamation of those ecosystems that have been damaged by hurricanes and past practices.

Forest Service Programs for Non-Indigenous Plants and Animals

The Forest Service has been an active participant in cooperative programs to prevent and control non-indigenous plants and animals. I would like to discuss several programs we have developed in cooperation with other countries and with other Federal agencies.

We are working with scientists from other countries to identify plants, fungi, insects, and other organisms that could be pests and to reduce the risk of their entry into the United States. The value of this international effort was evident when the Asian Gypsy Moth was discovered in Oregon and Washington in 1991. A Forest Service research scientist had cooperated with Russian scientists and also studied the Asian Gypsy Moth in Russia. The information he was able to provide was valuable in the eradication efforts conducted by the Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) and State agencies. Our Forest Pest Management staff is also working with the Russians to assist them in controlling pest outbreaks around their port areas to lessen the chances of exotic pests entering the United States on cargo from these ports.

Our coordination efforts with other Federal agencies include working with APHIS to develop a list of exotic pests and potential entry points into the United States. We are also cooperating with APHIS by providing assessments on the risks of importing logs and other unmanufactured wood products from Russia, Chile, and New Zealand.

In 1993, the Forest Service participated in organizing and facilitating the Department of Agriculture's Noxious Weed Coordination group. The group's role is to improve communications between the Department's agencies with weed responsibilities. The Forest Service is also a member of the team which developed the proposal to establish an inter-departmental team to coordinate Federal agency efforts for noxious weed control. Later this year, a memorandum of understanding will be signed by the agencies within the Departments of Agriculture, the Interior, Defense, and Transportation establishing the Federal Inter-Departmental Committee on Management of Noxious and Exotic Weeds. The Forest Service will serve as a co-chair of this committee.

Forest Service Activities

The Forest Service has also been active in revising its regulations and cooperative efforts at the program level for exotic plants and noxious weeds.

In 1993, the Forest Service conducted a field review to evaluate its current policy relative to noxious weeds. In December 1993, the current policy was published in the *Federal Register* to request public comments. The results of the field review and the public comments will be used to finalize Forest Service policy on noxious weeds and to incorporate an ecological approach to weed management.

The Forest Service has been effective in implementing both prevention and control programs for noxious weeds on national Forest System lands. We emphasize preventing the introduction of a noxious weed as the most important action. The most effective prevention programs are cooperative efforts with State and county weed organizations and surveys for invading noxious weeds conducted cooperatively by the Forest Service and livestock permittees on rangelands. In wilderness and backcountry areas, we are working with outfitters, guides, volunteers, and recreationists. In addition, noxious weed information for the public is provided at ranger district offices and recreation trailheads. A new prevention program developed for national Forests in Colorado and Wyoming will require all hay brought onto national Forest System lands to be certified as weed-free.

If prevention efforts fail, operations to control the noxious weed must be conducted. Similar to prevention programs, the most effective control operations are cooperative efforts between Federal, State, county, and private landowners. The control programs are usually designed to eradicate a noxious weed within a watershed to prevent the re-establishment of the noxious weed by water or animals after the control operation. To encourage these cooperative efforts to prevent and control noxious weeds, the Forest Service has helped to establish the Western Weed Coordinating Committee which focuses on coordinating noxious weed programs among all landowners. Other coordination actions include the sharing of equipment and personnel, combined training, and biological and chemical controls.

Research Efforts

When a new exotic pest is discovered in the United States, a series of immediate research activities must be conducted. These include research on how to survey and determine the extent of the infestation, how to prevent the spread of the pest, how to eradicate it, and what, if any, damage it will do in our ecosystems. Because introductions of exotic pests cannot be anticipated, it is difficult to build funding for this research into our program of work. We are working to solve this problem because this research is some of the most cost effective research we can do. Quickly coming up with the answers to prevent an exotic pest from becoming established or spreading can save billions of dollars.

In response to the exotic plant problem in Hawaii, the Forest Service is cooperating with the National Park Service, the Fish and Wildlife Service, the Hawaii State Department of Agriculture, the State Forester, and the University of Hawaii in a biological control program. The Forest Service's contribution to this effort is biological control using insects. We have been successful in finding, testing, and securing approval to release three insects on gorse, a weed that is particularly damaging to open rangelands in Hawaii.

A similar problem exists on national Forest System lands. As I mentioned earlier, many species of exotic plants are invading these lands. The Department of Agriculture's Agricultural Research Service (ARS) conducts much of the research on these exotic plants. ARS is presently conducting research on the 10 species that are of concern on pasture, forage, and rangelands. This means there is still research that needs to be completed on exotic plants affecting forest ecosystems. To initiate research efforts on these forest and rangeland ecosystem noxious weeds, the Forest Service is currently evaluating a proposal to co-locate a biological control research and development staff in Bozeman, MT, with ARS and Montana State University.

Summary

Exotic pests have changed the composition of our forest and rangeland ecosystems and have caused billions of dollars in damage to wildlife habitats, local economies, and forest resources. The costs of trying to control these pests and the cost of research have also been high.

The Forest Service supports the conclusions by the Office of Technology Assessment and others that exotic pests are a major threat to our native forest and rangeland ecosystems.

The Forest Service along with other agencies in the Department of Agriculture will continue to develop a more effective and coordinated response to prevent the

introduction of exotic pests and to control these pests where they have been introduced.

This completes my testimony. Dr. Sesco and I will be pleased to answer any questions you may have.

U.S. DEPARTMENT OF AGRICULTURE,
ANIMAL AND PLANT HEALTH INSPECTION SERVICE,
Washington, DC.

Dr. ISI A. SIDDIQUI,
Division of Plant Industry, California Department of Food and Agriculture, Sacramento, CA.

DEAR DR. SIDDIQUI: This is in response to your letter of August 19 on mail inspection in Hawaii. We appreciate your offer of assistance in this program. We are currently examining ways to improve Hawaii's program, to initiate a program in Puerto Rico, if possible, and most recently to implement a congressionally mandated program to protect Hawaii from pests which may enter that State from other States.

We have been aware of the limitations on Hawaii's program since its inception. We have examined the very problem you pointed out. It was found that very few parcels of quarantine interest are mailed from the islands on Fridays and weekends because postal patrons are aware of the effect of delays on the soft fruits that are of most concern to us. In addition, the delay problems with the mail and the inability to obtain warrants are very real ones.

The postal inspection system in Hawaii was set up after a long period of study and is operating on a delicate and carefully preserved balance of cooperation among the Postal Service, the Federal court system and APHIS. Quarantine is an art relying on many factors for its successful accomplishment, not an absolute science. We have found that the present program has substantially cut down the number of parcels being mailed. We are continuing our public relations efforts in the present fiscal year. The selected officers involved are most familiar with the mail system and believe the system now operating is the best presently available.

We will continue our efforts to assure quarantine security. We will strive for maximum improvement as we negotiate with the Postal Service, the Hawaii Department of Agriculture, and the Department of the Interior on mail inspection both in and out of Hawaii. Mr. Jim Reynolds indicated at the National Plant Board meeting that we would contact the Postal authorities concerning changes in operational procedures. We have contacted the Postal authorities in Honolulu to request their cooperation in permitting us to perform inspections on the weekend and hold parcels until a warrant can be obtained on Monday morning. We have not yet received a reply. However, they have indicated they are studying the applicable Postal regulations for a more positive interpretation. Should the present interpretation not change, we will pursue the matter at the national level.

We will continue to encourage legislation to permit mail inspection with a less onerous warrant system. At this time, we request only your support for such enabling legislation.

Sincerely,

B. GLEN LEE,
Deputy Administrator, Plant Protection and Quarantine.

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
Honolulu, Hawaii, March 9, 1994

Hon. DANIEL K. AKAKA
720 Hart Senate Office Building
Washington, DC 20510–1103

DEAR SENATOR AKAKA: This is to provide testimony for the March 11, 1994 hearing before the Senate Committee on Governmental Affairs regarding Federal policies governing the introduction of non-indigenous plant and animal species.

We believe that current actions to prevent the introduction of non-native plants and animals into Hawaii are very much inadequate, both at the State and Federal levels. Despite strong laws and regulations and competent professional inspectors and enforcement officers at ports-of-entry, a myriad of non-native pest plants and animals have become established in the Islands with devastating adverse impacts on indigenous flora and fauna and the agricultural economy. To correct current deficiencies in the process of intercepting prohibited species and/or eliminating their incipient populations, a significant increase in funding and manpower is needed within Federal agencies charged with detection and mitigation. The same is true for equivalent State of Hawaii agencies. In addition, interagency cooperation and integration of forces at the Federal (civilian and military agencies), State, County, local and private levels is absolutely essential to alien species prevention and control in our insular society.

Thank you for the opportunity to comment on this important issue.

Sincerely,

KEITH W. AHUE

PREPARED STATEMENT OF YUKIO KITAGAWA

Thank you for the opportunity to testify at this hearing on Federal policies governing the introduction of non-indigenous plant and animal species. Today, I would like to discuss two issues: The Alien Species Prevention and Enforcement Act and USDA's Risk Assessment Policy.

During the past year, officials with the State of Hawaii, Department of Agriculture, have met several times with representatives of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ), the U.S. Fish and Wildlife Service, and the U.S. Postal Service to implement the "Alien Species Prevention and Enforcement Act." This Act was signed into law (P.L. 102–393, 106 Stat. 1774) on October 6, 1992, and required that, within 90 days of enactment, the U.S. Postal Service and the Secretaries of Agriculture and the Interior offer to enter into a cooperative agreement with the State of Hawaii to enforce plant and animal laws within the jurisdiction of these agencies. This legislation further required USDA-APHIS-PPQ 2 years to expend just as much effort in Hawaii to inspecting incoming first class mail as outgoing first class mail to prevent the entry of pests into Hawaii and to survey the extent of the problem of pest movement in first class mail arriving in Hawaii.

While we acknowledge the efforts of all three Federal agencies in trying to implement the provisions of this Act, we are certainly not satisfied with the results. To date, there is still no Federal inspection for incoming first class mail to prevent the entry of harmful plant pests and diseases and illegal animals into the State of Hawaii as provided by the Act. Furthermore, over a year has already lapsed in this proposed 2-year project.

As we understand it, the following summarizes the situation of each affected State and Federal agency:

1. State of Hawaii laws and rules treat all plant-feeding insects, arthropods, invertebrates, and vertebrates of equal importance in that all have the potential of becoming significant economic pests in our islands. As such, a large number of plants and all non-domestic animals and microorganisms are regulated and require permits for entry into the State.
2. U.S Postal Service has ruled that First Class Mail privileges, including the sanctity of privacy, extends to parcels as well. Therefore, first class mail parcels cannot be examined without a Federal warrant even if the parcels are clearly marked as containing live plants or animals.
3. U.S. Fish and Wildlife Service maintains that provisions of the Lacey Act can only be invoked after a violation has been observed. The Lacey Act is needed to allow State of Hawaii violations to become Federal violations. However, since the U.S. Fish and Wildlife Service has no inspection authority, the Lacey Act cannot be invoked to inspect mail parcels.

4. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine maintains that their authority to conduct inspections do not extend beyond their inspection for specific plant pests designated under USDA's 15 Federal quarantines, many of which are to keep Hawaii's pests from leaving the islands. The department also maintains that Federal magistrates would not issue warrants for pests that are confirmed by detector dogs because of Hawaii's broad definition of a pest under State law and rules.

What we have then is a State that would like equal protection from alien species, a U.S. Postal Service that will allow for inspections through search warrant procedures, a U.S. Fish and Wildlife Service that can invoke State laws only after a violation occurs, and a U.S. Department of Agriculture, which has inspection authority, but only for a select number of plant pests that for the most part are of little concern to Hawaii. Since USDA-APHIS-PPQ currently inspects outgoing mail, specific language must be developed in this Act to give this agency the authority to also inspect incoming domestic mail for plant and animal pests as designated under Hawaii law.

Our efforts to implement the Alien Species Prevention and Enforcement Act have been very frustrating to say the least. Each year, new pests are discovered in our islands causing problems to our growers and citizens. We continually capture or confiscate prohibited animals, many of which have been turned loose or have escaped. Last fiscal year (July 1, 1992 to June 30, 1993) alone, we captured, confiscated, or investigated 42 lizards, 18 snakes, 22 turtles, 13 mammals, 25 oirds, 119 amphibians, and over 5,000 arthropods that were illegal to possess in Hawaii. Many of these animals probably entered the State under the "protection" of the first class mail pathway.

The second issue deals with USDA-APHIS-PPQ's Risk Assessment Policy and policy on "quarantine action pests." We understand that USDA-APHIS-PPQ policy requires Federal inspectors to take action only on "quarantine pests" that enter Hawaii from foreign areas. All other pests are referred to state inspectors, if available. Perhaps it is time to review this policy in light of Hawaii's unique situation. it may be that other States may also have unique situations as Hawaii.

Unlike most other States, Hawaii's (1) heavy reliance on imports; (2) mild climate; (3) diverse vegetation; and (4) lack of natural enemies result in a larger influx of pests into the State from foreign areas, and a higher probability of those pests becoming established and causing damages. Furthermore, USDA-APHIS-PPQ's recent adoption of a "risk assessment policy on plants grown in media" that is based on the economic importance of the crop places many of Hawaii's important crops in jeopardy because of the minor crop status in the U.S. of Hawaii's economically important crops.

Hawaii's limited island resources place a high demand on imports from abroad. The ratio of total imports to Hawaii's gross State product is now 60 percent as compared to 10 percent for the total continental U.S. economy. This heavy reliance on imports means a greater potential of pests being transported to Hawaii from both foreign and domestic areas.

Establishment is relatively easy once the pest arrives. Our subtropical climate, further moderated by the Pacific, provides year-round development for pest populations. Approximately 75 crops are commercially grown in Hawaii. Thousands of other plant species—collected from temperate, subtropical, and tropical areas throughout the world—are used in Hawaii's landscaping, pastures, forests, and conservation areas. Insects from abroad would have no difficulty in finding a suitable host in Hawaii.

Because of our geographical isolation, Hawaii is also relatively devoid of the natural enemies common to continental areas, further making it easier for a pest to become established. it is well known that the introduction of insects, previously thought to be innocuous or of minor significance, have had devastating effects on Hawaii's plant life and economy.

Hawaii can no longer afford to act as a "stepping stone" or "buffer" for pests moving from the Orient, South Pacific, and Tropical America into the continental U.S. USDA-APHIS-PPQ needs to give Federal PPQ inspectors broader authority to take quarantine action on all pests entering Hawaii from foreign areas. Decisions on what is a quarantine action pest in Hawai—should not be based on a risk assessment that has evolved from knowledge of continental crops and economics—but rather from one that is based on sound knowledge of local environmental and economic factors. For Hawaii and other tropical/subtropical areas, all organisms that feed on plants, or compete with other plants, should be treated as a potential quarantine action pest.

It is not surprising that when we conducted a study on the possible sources of pest origin into Hawaii between 1975–1985 that 76 percent of our new pests had originated from foreign areas. It is also not surprising that 16 percent had also originated from Tropical America where there was no direct air or sea traffic to Hawaii. We have long been concerned about the movement of pests from Central and South America through international hubs in the continental U.S. into Hawaii. Part of this problem lies in a policy that takes remedial action only for "known pests" of "significant risk" to the continental U.S. Case in point is the large number of orchids and other tropicals that flow virtually unrestricted into the U.S., ultimately bringing pest problems to Hawaii.

Many of Hawaii's pests can be attributed to the first class mail pathway and USDA's risk assessment policy. For example, it takes only one gravid snake to suddenly remove "paradise" from Hawaii. And yet, "paradise" is what fuels our primary industry, tourism. "Paradise" nurtures our native plants and animals. "Paradise" is what makes Hawaii our home. That is how serious the problem is.

Thank you for the opportunity to testify at this hearing.

PREPARED STATEMENT OF KENNETH Y. KANESHIRO, PH.D.

Thank you for the opportunity to provide input on the impact of non-indigenous species in the United States, especially in the State of Hawaii. The recent findings of the Office of Technology Assessment identified Hawaii as one of the two states (Florida being the other) with particularly severe non-indigenous species problems. The conservation agencies in Hawaii, including Federal, State, and non-governmental organizations, have set the mitigation of non-indigenous species as the top priority in order to protect our state's fragile island ecosystem. As Director of the Center for Conservation Research & Training at the University of Hawaii, I present some of my thoughts on this issue.

Hawaii's Unique Ecosystem

Hawaii ranks number one in the world for its tally of endemic species, even though it encompasses less than two-tenths of one percent of the planet's total land surface. Almost 100 percent of its invertebrate species (estimated to be about 8,000 species), 98 percent of its birds (about 100 species) and 93 percent of its flowering plants (about 1,400 species) occur nowhere else on earth. Minnesota by contrast, has only one endemic plant.

The Hawaiian Archipelago, formed in isolation in the mid-Pacific Ocean by a time-sequence series of volcano formation, is considered by many scientists to be the world's most outstanding living laboratory for the study of evolutionary biology. Over the ages, a great variety of life forms developed that were specially adapted to the conditions in Hawaii's widely-differing ecological zones. Hawaii's incredible native flora and fauna, comprising thousands of species unique to the islands, is renowned for its examples both of nature's creativity and her vulnerability.

Biodiversity

Biologists consider that biological diversity is a crucial part of life systems because of the interdependencies that link flora and fauna and because variation within species allows them to adapt to the challenges of an ever-changing environment. Given the complex workings of an ecosystem, it is never clear which species, if any, are expendable.

Studies have shown that the greatest diversity of organisms occur in the tropics. Between 50 percent and 80 percent of the species on earth are found in tropical forests which encompass less than 7 percent of the planet's surface. While global environmental issues have focused on the destruction of huge tracts of tropical rainforests in Central and South America and in Southeast Asia, we have similar problems here in the United States especially in Hawaii. The extinction of unique life-forms in Hawaii, both plants and animals, far exceed that occurring on the continental United States. Our island ecosystem is extremely fragile and is highly susceptible to perturbation caused by human activities. With the planet's greatest toll of extinct species for a given land area, Hawaii also epitomizes the plight of threatened ecosystems worldwide.

Biotechnology

During the last two decades, major breakthroughs in the study of basic biology have occurred. It is now becoming increasingly possible to explain biological processes in molecular terms. The very powerful techniques developed by the field of molecular genetics have become the basis of a new technological revolution called bio-

technology. With this technology, it has become possible for man to intervene in the processes of natural evolution for producing useful products.

Natural genetic diversity in the tropical flora and fauna of the world represents a storehouse of genetic information most of which we know very little about. The University of Hawaii's Biotechnology Program intends to take full advantage of the genetic resources available in our native ecosystem. Genes that are specifically adapted to our tropical environment can be engineered into agricultural crops for improving them. For instance, genes isolated from salt-tolerant, drought-tolerant or disease- and pest-tolerant native plants can be isolated and transferred to commercial crops for making them resistant to these factors. New strains of nitrogen fixing bacteria that are specifically effective in the acidic soils of the tropics can be developed. Useful genes from tropical fresh water and salt water fishes can be isolated and used to improve aquaculture. The fresh water and marine tropical environment of Hawaii contains thousands of unexplored species of algae and seaweeds potentially rich in unknown natural products beneficial to man. The genes encoding these compounds can be isolated and made use of for man's benefit. Therefore, it is of the utmost importance to preserve Hawaii's native species, not only for the study of natural evolution, but also for the economic opportunities they offer through biotechnology.

Impacts of Non-Indigenous Species

Almost the whole of the native Hawaiian flora and fauna—98 percent—is endemic to these islands, found nowhere else in the world. Discovery and occupation by humans, first Polynesians and then Europeans, led to gross disturbance of the natural environment through habitat loss, the introduction of alien browsers, predators, birds and plants. The native plants and animals that had evolved in an era without browsing or predatory mammals, faced the onslaught of tens of thousands of goats, pigs and deer, and many pest plants spreading through the forests and other ecosystems.

These disturbances have resulted in the loss of ecosystems, the extinction of numerous plants, birds, insects and other animal life and drastic population reductions in many more plant and animal species. Hawaiian plants and animals currently account for 27 percent of our Nation's rare and endangered species. More than 70 percent of the extinctions recorded in the U.S. in the past two decades were of plants and animals once found only in Hawaii.

New pest species continue to become established in Hawaii and there is a great potential for even more harmful ones to be introduced. The introduced animal problems include:

Pigs: disturbing the forest floor vegetation; preventing regeneration of plants, both rare and common; causing water deterioration.

Goats: eating plants of the forest floor and lower forest undergrowth; killing trees by barkstripping;

Rats: preying on the nests of rare birds, on rare snails, and probably other fauna; destroying the seeds of rare plants.

Mongooses: preying on rare birds.

Feral cats: preying on rare birds.

Mosquitoes: infecting native birds with malaria.

New alien insects have been introduced, accidentally and deliberately, in a steady stream. Even today, with modern surveillance at the ports, airports and postal services, 23 new insects were recorded as becoming established in 1991. As many as 2,500 alien arthropod species may now live here. These insects can attack and eradicate "keystone" species that others depend upon. A simple example is the ants that attack the native bee that pollinates the beautiful Haleakala silversword, so indirectly threatening the silversword's continued existence.

Hawaii is an excellent growing climate for the many trees, shrubs, garden plants, grasses and weeds that humans have introduced, whether purposely or accidentally. There are now more than 800 alien plants established in the wild.

An introduced vine, the banana poka of the passionfruit family, smothers pristine native forest, cutting out the light from the tree crowns and shading the forest floor so much that some plants can no longer grow there. Kahili ginger, introduced for its flowers, takes over the floor of the forest and crowds out the native plants. When the current overstory of trees die in their natural cycle, will there be any native plants to replace them? These are but two of the many plant pest species seriously degrading Hawaii's natural environment.

Promising work is being done on the biological control of several of the worst weeds but biological control research is expensive. With present resources, nothing

can be done about the dozens of other serious weed problems. The most cost-effective way of dealing with unwanted pest species is to prevent them from ever entering the State.

The Extinction of Hawaii's Native Plants and Animals

With only 0.2 percent of the land area of the United Sates, Hawaii has 75 percent of the Nation's known extinctions. Of 140 Hawaiian birds, 70 have gone extinct since the arrival of humans. Of the 70 forest birds still in existence, 30 are threatened or endangered. For many of these birds, we know very little about their biology and even less of the specific causes—is it loss of habitat? Introduced disease? Predation of the nests?

Plants have fared no better. As of June, 1992, 85 Hawaiian plants were listed by the US Fish & Wildlife Service as endangered and more than 103 species are scheduled to be added in the near future. About a dozen plant species have been reduced to a single individual.

The Hawaii Conservation Biology Initiative (HCBI) report "Immediate Research Needs of Hawaiian Natural Area Managers", which was prepared in 1992 by a group consisting mainly of management-oriented people, identified the alien plant problem as the highest priority for research on natural resource management problems in Hawaii. The report identified the problem of the impact of feral pigs on native ecosystems as another of the highest priorities.

Following on from that report, an HCBI workshop on research priorities for forest birds identified introduced diseases of birds, and predation by introduced rats, mongooses and feral cats as being critical factors in the decline of bird numbers. A second workshop to identify the priorities for research on alien plants, gave the highest priority to preventing plants that are potential invasive weeds from entering the State and becoming established. The report of the workshop concluded

> "Not enough is being done. to prevent the entry and establishment of harmful plants in Hawaii. Inasmuch as new legislation needs to be passed or existing laws need to be enforced, the solutions to this problem are partly political."

Economic Impact

The economic crops grown in the Hawaiian islands have also been seriously impacted by introduced pest species. It has been estimated that the alien fruit fly species, the Mediterranean, Oriental, and melon flies, cost Hawaii $300 million annually in lost markets for locally grown produce. These same species are also threats to California's multi-billion dollar fruit and vegetable industry. Nearly a million dollars a year are expended by State of Hawaii for research to control or eliminate impact of alien species on agricultural commodities.

The Formosan subterranean termite, another alien species to our islands since the early 1900's, cause millions of dollars of damage each year to residential and industry structures. In 1985, a conservative estimate to prevent infestation, to undertake remedial control, and to repair damage caused by this species in Hawaii was $50 million per year.

The tourist trade, on which the State's economy depends, could be impacted in the future. If the mosquito that carries human malaria were to be introduced to Hawaii, it could pick up the malarial parasite from visitors from some parts of the world and start the human malaria cycle in Hawaii. If future intending visitors to Hawaii need to dose themselves with anti-malarial drugs before they leave home and worry about the brown tree snake biting their babies while they sleep (as happens in Guam) the impact on the tourist trade could be disastrous. If (when) the snake and/or human malaria are found to be established in Hawaii it is predictable that many costly emergency actions will be taken—but it will be too late.

As well as its impact on the native bird life and its nuisance value to humans, the brown tree snake causes millions of dollars worth of damage in electrical outages on Guam. There is no reason to think the economic impact on Hawaii would not be proportionally equivalent.

The Quarantine Problem

The liberalization of world trade through the General Agreement on Tariffs and Trade and the North American Free Trade Agreement, which will bring about an increased flow of goods between countries, can only exacerbate the transfer of organisms from country to country. These developments should be accompanied by the trading partners making a renewed commitment to slowing the international spread of pests and diseases through the setting and policing of more stringent quarantine and surveillance policies.

Part of the problem for Hawaii is that although it is unique and its ecosystems are totally different from any on the continental USA, it is legally a State of the United States and therefore international quarantine treaties do not apply for visitors and goods from the mainland to Hawaii. Federal laws and rules aim to protect large-scale mainland agriculture by preventing pests established in Hawaii from entering the mainland, but this protection is not reciprocal: the same kinds of precautions are not taken with goods moving from the mainland to Hawaii. The continental U.S.A. is estimated to be one of the main sources of new pest organisms, contributing around 26 percent of those that became established between 1981 and 1990. Decreasing the introductions from that source would not solve all of Hawaii's problems but it would certainly help. Ideally, the law should recognize Hawaii's vulnerability and enable the mainland U.S.A. to be treated as a "foreign" country for the purposes of quarantine in Hawaii.

An alien species that has been intercepted at Hawaii but has not to our knowledge become established here is the brown tree snake, which has caused the extinction of nine of Guam's eleven forest birds. So many of Hawaii's birds are already rare that the establishment of the snake would be a disaster of major proportions. I believe it is of the utmost importance that detection measures be improved, that an effective fumigant be identified for killing the snake where it is known or suspected to be in cargo, and that a means of luring/poisoning it be developed. It is essential that such means of combatting the snake be developed without delay.

Hawaii's natural environment has been badly damaged by events of the past but there is still a tremendous amount remaining that is of scientific, aesthetic, and cultural value that needs to be protected. It is simply inviting disaster to fail to take effective action to prevent the entry of these and other pest species.

Drastic international and national advances in setting and maintaining standards are needed if the laws and regulations and the agencies that administer them are to prevent further degradation of the ecosystems, plants and animals that belong only in the Hawaiian islands. The time for urgency is now.

PREPARED STATEMENT OF WALTER R. COURTENAY, JR., PH.D.

At least 70 fish species, imported from beyond the borders of the United States, and well over 160 native species transplanted beyond their historical ranges of distribution are now established as reproducing populations in novel habitats in waters of the United States. That figure of 160 native species represents about 20 percent of the U.S. fish fauna, and is probably an underestimate, as stated in my report, derived from published literature; in fact, on February 20, 1994, I was advised by a researcher with the National Biological Survey that their new investigations indicate that closer to 50 percent of our native fishes have been moved by humans beyond native ranges.

How did fishes get moved? Early introductions were made to "improve" a mostly unknown native fish fauna for food and sport purposes, but most intentional introductions within the present century were made only to provide for sport fishing. Other fishes were introduced for aquaculture or for biological control uses, and a few endemic species were moved to protect them from almost certain extinction in their native habitats. Fish culture, or aquaculture of fishes, usually is accompanied by escapes. Other fishes were released by hobbyists, some (like the zebra mussel) from foreign ballast water releases, and through canals or other waterways built to connect drainage basins. A major source of fish transfers within the U.S. has been anglers releasing bait fishes netted from other drainage systems or bought from "bait shops" (fishes cultured in other States from other parts of the U.S. or of foreign origin).

Were any of the intentional introductions made after research on their possible negative impacts, or released only because of some perceived need that might be met by their introduction? No and yes, in that order.

Have any of the introductions been beneficial? Yes, a very few, but not without their own problems to indigenous fishes in various locales. Sport fishing is largely dependent on stocking and introductions, and rarely have such releases had any positive biological impact to receiving habitats and ecosystems. I say this as a sport angler who is also concerned with protecting fish communities. Moreover, introductions have often made managing fisheries more difficult in several instances because introduction urges surpassed ecological concerns.

Have any of the introductions been detrimental? Yes, many, including some that have caused extinctions. In a 1989 listing of fishes of North America considered endangered, threatened, or of special concern, 41 percent of those fishes were cited as having been negatively impacted by non indigenous fish introductions.

What have been the costs? Substantial over time, but primarily with the sea lamprey in the Great Lakes. GAO says that about $10 million per year is spent on lamprey control, an equal amount in stocking fishes in the Great Lakes, an admitted drop in the bucket of Federal spending, but to not do so could cost $500 million annually in lost values. The recently (about 1986) introduced ruffe, a fish from Europe, could cost $90 million per year in lost revenue as a result of its future potential damage to Great Lakes fisheries and related businesses. Some State and Federal agencies are now trying to eradicate previously transplanted native fishes to assure survival of equally economically important native fishes. Nevertheless, dollar values cannot be placed on any one or all species within a biological community, and is a patently unjust way to judge their worth. The health of aquatic resources is in its biodiversity, water quality, and the inner workings of ecological interactions of each species with its environment—unmeasurable in economic terms. Only when, by human error (including introductions), habitats or parts of ecosystems collapse do we begin to feel an economic impact at the time it effects some species that we depend on. Our value system seems to lack a sense of recognition that everything cannot be measured in dollars, and pays little attention to necessary stewardship for our biological resources, whether or not they are consumable.

How did this situation come about? It happened because from the start, fisheries resource agencies, Federal and State, were created to provide the public with catchable fishes, for commercial or recreational purposes. None of these agencies was established to be a conservation agency, although that is how most of the public views them. Thus, those agencies have often opted to manage for fishing—not necessarily for fishes. The Federal Government set the example, and the other entities followed. States inherited most of this task because the Constitution allowed them to do so.

Where do we go from here? First, the Federal Government must set a new example to be followed by creating a policy on introductions that recognizes the non-economic values of biological entities and requires extensive research and peer review on potential impacts before (or if) introductions are permitted to be made. Without that leadership, this mission will fail. Secondly, States need to be cooperating on an ecosystem basis rather than doing what each one feels best for its own interests (= fishes do not recognize political boundaries) with introductions. The weapon to make certain that these things happen is financial aid to States, under control of the Federal Government.

PREPARED STATEMENT OF BRUCE E. COBLENTZ

Non-indigenous species (hereafter called exotics) are those species not native to a particular biotic community that have been introduced via human activity. Exotics that undergo rapid population growth and range extension from their point of introduction are generally referred to as being invasive.

Exotics, and especially invasive exotics, are substantially different from other forms of ecological disturbance. Whereas the environmental effects of pollution, overharvesting, poor grazing practices, and even strip-mining can be expected to diminish over time after the offending activity is halted, exotic organisms, once established in a community, are usually permanent. Thus, if we are having a severe effect on the biota of a river by allowing some pollutant to enter, that effect will progressively diminish once the source of the pollution is terminated. Conversely, if a handful of zebra mussels (*Dreissena*) are put into the same river, the effects of those mussels and their multitudinous descendants will probably be permanent. Although the zebra mussel example is perhaps the most discussed recent exotic species nightmare, and projected costs associated with it are over $4 billion over the decade of the 90's, it is far from being the most calamitous introduction into North America, even when considering that the $4 billion estimate does not begin to account for loss of productivity of native species or even extinctions of native species due to usurped space or nutrient resources.

In 1492, Columbus and his party landed on the island of Hispanola in the Caribbean. There may have been over one million indigenous people living there at the time of first contact. When Columbus again landed on Hispanola only 2 years later, the majority of the indigenous people had perished due to smallpox (*Variola*), a virus not native to the new world. In fact, smallpox was not even native to the Europe that it so thoroughly infected for several centuries. Its origin was apparently in East Asia, having been brought by traders first to the middle east: from there it travelled on to Europe with the returning crusaders. Considering that after European contact, more indigenous North and South American humans died from small-

pox than from any other cause, this surely must have been the most devastating exotic from the human perspective.

Disease organisms (and parasites) are among the most completely devastating exotics when one considers their potential to completely eliminate a susceptable species. Thus, important tree species such as American chestnut (*Castanea dentata*) and American elm (*Ulmus americana*) of the eastern deciduous forest biome have been essentially eliminated, and may well be faced with extinction. Additionally, flowering and Pacific dogwoods (*Cornus florida* and *Cornus nuttalli* respectively) and butternut (*Juglans cinerea*) are currently in precipitous decline due to exotic diseases of uncertain origin.

Of even greater current concern are those tree species that provide the majority of lumber for construction. Although numerous diseases and parasitic organisms (including insects) have already become established, few at present seem destined to eliminate any commercially valuable conifer species. However, that soon may change. Ill-advised and ecologically irresponsible plans to import raw logs for milling in this country carry only a single certainty with them, that they will surely introduce insect or disease pests that will have a net negative economic and biological effect.

The United States is currently the world's largest producer of industrial roundwood by a wide margin (U.N.F.A.O. 1993. Forest Products Yearbook, 1991. Rome). We produce 26 percent of the world's supply in a Nation of well less than 5 percent of the global population. To propose importation of additional logs that have the potential to jeopardise the viability of the world's largest wood products industry is at best naive, short-sighted, and perhaps unthinkably mercenary. In common language it is exceedingly stupid. There are other, more insidious ways that exotic organisms impact species and communities. In general, there is only so much space, food, or other resources in any environment. Thus, in a given forest there is only so much space where frees can grow. They are limited by the nutrients in the soil, and the availability of sunlight in the canopy. Any space on the ground or in the canopy that is usurped by an exotic species equates to a commensurate loss of biomass of one or more members of the native flora.

Although in general a natural forest community will not be invaded by an exotic tree, there are ways in which it can happen. Most of the exotic trees of concern (ex. Chinese Tree-of-Heaven, *Ailanthus altissima*) exploit disturbed sites. They colonize areas by spreading along road corridors, and generally produce large numbers of easily dispersed seeds which settle throughout undisturbed habitat. As long as there is no disturbance the exotic is not likely to be a concern: however, forest communities have a background level of predictable disturbance from windthrow, lightning strike, ice-storms, and other natural causes such as old-age mortality of individual trees. When there is a large seed source "waiting" for any such disturbance, disturbed sites are often quickly colonized by aggressive invaders. Although such an invasion is rapid in ecological time, it may appear imperceptably slow to a human observer who generally has a lifespan considerably less than the period required for significant forest community conversion. The end product of such a scenario may well be a forest dominated by a valueless invasive exotic tree species, and if that exotic is of little value to native fauna, an impoverished animal community.

Aquatic communities are affected in ways similar to forest communities in that a body of water essentially has a relatively finite capacity to produce, for example, fish. If an invasive fish species is introduced into an aquatic community, and it increases in number and biomass, there will be a roughly commensurate decrease in the native fish. With the introduction of carp (*Cyprinnus carpio*) in North America, their rapid continental invasion resulted in a permanent foregone production of more desirable native species roughly equal to carp biomass, and that amount of fish is a substantial portion of the total North American fish biomass. Perhaps the best North American example of this phenomenon is the introduction of the ruffe (*Gymnocephalus cernus*) into Duluth Harbor in Lake Superior in the 1980's. Presumably carried from Europe in ballast water, it was first collected in 1986. By September 1992 it had replaced 50 percent of the fish biomass in the area sampled in Duluth Harbor, and only a year later the biomass replacement level reached 99 percent. We might speculate that the 1 percent of remaining native fish biomass does not represent populations with a secure future. If the ruffe spreads throughout the Great Lakes, the loss of native fish biomass will be extraordinary.

There is little hope for controlling invasive exotics like the ruffe; eradication is a mere pipe-dream. Like it or not, such exotic species, once introduced, are part of a new North American biota, and usually a new biota a significantly less value, use, or esthetic appeal. Such biota are degraded and in many ways we are poorer for it; often native species are eliminated or severely reduced.

Control or eradication are often too expensive to consider or just plain impossible; in many instances the only action that has a reasonable chance of success is prevention. Prevention, too, is difficult, but unlike after-the-fact measures it may be generally achievable. The problem with prevention is that there are always special interests that either want exemptions, or individuals that disagree with such policies and unilaterally circumvent them. The professions of wildlife and fisheries management have often elevated species introductions to the level of a cottage industry. Some of the most serious exotic pests have been deliberately introduced by such professionals. Some State and Federal agencies have reached a level where they perceive the problems associated with exotics, some clearly have not. The horticulture industry profits from the sale of non-native plants, many of which naturalize and can be invasive. Without strict and uniform laws preventing introductions and the ability to block introductions, they will continue unabated as long as the public remains uneducated about the negative effects of exotics.

An educated public is unlikely. Even a public in agreement about any environmental or natural resource issue is unlikely. Perhaps a better target for education is all the elected and appointed officials in Washington, D.C.; they have the capacity to act on their knowledge, and Congress has already demonstrated its lack of understanding of the ecological implications of exotic organisms by the passage of Public Law 92–195, The Wild Free-Roaming Horses and Burros Act of 1971. PL 92–195 directs that feral equids be considered "an integral part of the natural system of public lands." Feral equids in North America are not natural. They were introduced by Europeans and have had about 500,000 years of separate evolution from the North American equids that went extinct at the close of the Pleistocene. One can only presume that Congress was declaring invalid a half million years of separate evolution, and was furthermore invalidating the extinction of North American equids. Besides being ecologically irresponsible, it was a rather arrogant usurping of powers that mortals simply do not have. Why not also declare the carp to be an integral part of the natural system of public lands?

The point of the above discussion is that for exotic organisms there are often two perspectives. Ecologically there can be no room for compromise. Invasive species are detrimental to natural ecosystems. In one sense they are like time-bombs in that one may not know if or how long it takes for an exotic species to generate a major negative effect. In another sense they are like tickets in a lottery. Less than one ticket in a million is a lottery winner; exotic organisms probably have a similar chance of being of benefit to indigenous biotic communities. Similar to lotteries each chance costs very little making it attractive to keep trying. The difference is that with exotic organisms, each "losing ticket" affects the subsequent ability of all players to afford to play the game. The costs of exotic organisms are a toll exacted on all the players. It is a wonder that any exotic species are ever seriously considered for introduction: it is a wonder that we haven't been protecting our biota and ourselves from this menace.

In summary, invasive exotic organisms carry a high probability of causing severe economic damage to valuable biotic natural resources, reductions in biodiversity up to and including species extinctions, foregone production and biomass of native biota, and in some instances severe economic costs due to damage in human dominated environments. This latter category includes a diversity of problems from dikes and levees collapsing because of tunneling by nutria (*Myocastor coypu*) to clogging intake pipes by zebra mussels. Since the costs associated with established exotics are essentially forever, the costs associated with preventing their introduction should logically be considerably less by comparison. Clearly, the preferred action when dealing with exotics should be prevention, with control or eradication a separate and secondary program to be employed where judged both essential and achievable.

Lastly, laws pertaining to exotic organisms must be Federal. Although various State land and natural resource agencies have different opinions concerning exotics, the organisms have little awareness or regard for jurisdictional boundaries. Again, an ounce of prevention is preferable to a regularly applied, *ad infinitum* pound of cure.

PREPARED STATEMENT OF DUCKS UNLIMITED, INC.

Ducks Unlimited (DU) is the largest wetland habitat conservation organization in North America. Since 1937, DU has conserved or restored 6.2 million acres of wetlands or associated upland habitats. This restoration effort has largely been accomplished by emulating natural hydrological cycles in modified wetland complexes and restoring native wetland plant communities. In addition, DU has been extensively

involved in research projects seeking to find improved ways of restoring natural wetland functions and values.

During the last century, approximately 4,500 non-native species of plants and animals have been introduced to the U.S. This invasion of species has created competition with native organisms that can be problematic and costly to control. The U.S. Fish and Wildlife Service annually spends hundreds of thousands of scarce operating dollars attempting to control exotic wetland plants within the National Wildlife Refuge System. For example, control of purple loosestrife (*Lythrum alicaria*) in wetlands of the Upper Midwest and carp (*Cyprinus carpio*) within floodplain wetlands of the Mississippi Valley has become an annual battle for State and Federal biologists. In some States, particularly Hawaii, non-native plants and animals pose threats to endangered indigenous species. In addition, the U.S. Office of Technology Assessment has released a report suggesting that non-native species may cause as much as $97 million in damages to U.S. agriculture.

Purple Loosestrife

Purple loosestrife is an aggressive, exotic perennial that displaces many natural wetland plants and degrades wetland functions and values throughout the temperate region of North America. The spread of this species has been enhanced by the absence of natural enemies and disturbance of wetland systems by humans. The plant now occurs in dense stands throughout the northeastern U.S., the Midwest, and in scattered locations in the western U.S. and Canada. Newly created irrigation systems in many western States have facilitated further establishment and spread of purple loosestrife.

The competitive advantage of purple loosestrife over other wetland plants is highlighted by such attributes as high annual seed production (greater than 2M seeds/mature plant), good seed viability (almost 100 percent germination; 80 percent after 2–3 years submergence), high seedling densities (10,000–20,000/sq. meter) and rapid growth (1 cm/day). Mature plants often have 30 or more shoots arising from the rootstock. These can reach 6–7 feet in height, forming dense canopies which severely restrict the amount of light available to plants beneath. Such stands also offer little in the way of food or cover for most forms of wetland wildlife including waterfowl.

The negative impacts on aquatic ecosystems caused by invasions of purple loosestrife far outweigh any of its attributes. The species forms large monotypic stands that reduce the biotic diversity of wetland systems by replacing diverse, productive emergent and submergent plant communities with a single species. Invasion of wetlands by loosestrife negatively impacts fish spawning sites, nutrient cycling, and invertebrate productivity and drastically reduces vertebrate species use.

Strategies for controlling purple loosestrife have included physical removal of plants, mowing, burning, water level manipulation, and the use of plant competitors and chemicals. None have proven effective over a broad range of conditions. Additionally, each methodology is costly and requires continuous treatment. Recently, biological controls using natural "enemies" (insects, pathogens, etc.) of purple loosestrife have shown promise. Such biological control offers the greatest potential as a long-term, safe, economical, and effective control technique and should be supported.

Common Carp

After initial introduction in the late 1800s, common carp are now a wide spread exotic pest in aquatic ecosystems across North America. They are most common in the Mississippi and Missouri River systems and have expanded northward to 60 degree July isotherm.

The profound impact carp have had on the ecological productivity and diversity of riverine, lacustrine, and palystrine wetland systems is well documented. Overabundant populations of carp can consume large quantities of submerged aquatic wetland plants, thereby directly affecting both plant and waterfowl productivity. In addition, the characteristic bottom feeding habits of carp increases turbidity of waters and disturbs and impacts aquatic plant growth and reproduction.

Control of carp has taxed the ingenuity and finances of conservation agencies for more than 80 years. Increasing restrictions in the use of piscicides and other similar piscicultural techniques have reduced the ability of fish and wildlife managers to address carp infestation problems. In many instances, the only management option to restoring functioning wetlands is to completely impound wetlands and, through water-level manipulations, exclude carp from them.

In response to the 1993 flood, recent planning efforts by the U.S. Fish and Wildlife Service for National Wildlife Refuges along major rivers in the Midwest calls for eliminating impoundments or reducing impoundment management for wildlife on refuge lands. This action would reduce biological diversity of the refuge system

by exposing managed herbaceous wetland complexes (a threatened plant community type in river floodplains) to the negative impacts of carp, siltation, woody plant invasion, and unnatural flooding episodes. We would urge the Federal Government to consider the possible impact of carp on Federal lands that would be converted from managed impoundments to nonstructural management.

Exotics in Hawaii

Although the incidence of non-native plants is great in California, Texas, and Florida, in no State is it more obvious than Hawaii. Estimates suggest that five to eight new exotic species of vegetation arrive in this State each year despite control efforts by the U.S. Department of Agriculture. DU's program in Hawaii has emphasized restoration of quality habitat for North American and Asian waterfowl species, which winter on the islands, and for four federally endangered waterbirds. Our current projects include work with the U.S. Fish and Wildlife Service on Oahu and Kauai, a cooperative effort with the Parker Ranch, Hawaii Department of Forestry and Wildlife (DOFAW), the Fish and Wildlife Service on Big Island, and work on Hamakua Canal wetland with Kaneohe Ranch and DOFAW.

Threats to the four endangered waterbirds come from a host of non-native species which include plants, feral mallards, and introduced mongoose (*Herpestes auropunctaus*). Exotic plant species, such as California grass (*Brachiaria mutica*), water hyacinth (*Eichhornia crassipes*), pickleweed (*Batis maritima*), and red mangrove (*Rhiszophora mangle*) all present serious problems in many wetlands by eliminating interspersion of open water and vegetation and by outcompeting more desirable native vegetation. Where the U.S. Fish and Wildlife Service eradicated California grass and other exotic plant species on James Campbell NWR on Oahu and Hanalei NWR on Kauai, and then replicated shallow seasonal flooding, response by native and migrant waterbirds was substantial. At Hanalei NWR alone, clearing of exotic vegetation on two 40-acre impoundments in the late 1980s resulted in the habitat use by more endangered Hawaiian duck (*Anas wyvukkuaba*) than were thought to exist on the entire islands.

Introductions of exotic mammalian predators have negatively affected waterbird populations across the Pacific Islands, and Hawaii has not escaped this catastrophe. The mongoose was first introduced to Maui, Molokai, and Oahu to control rats in sugarcane fields. Unfortunately, rats are nocturnal and mongoose are diurnal, so they rarely interact. Mongoose has been implicated as a very serious predator on native waterbirds and their nests. Feral cats and dogs also may prey on waterbirds on marginal habitats, as quality waterbird habitat has been reduced on the islands. Federal and State dollars are needed to improve the quality of existing wetlands and restore certain key wetland complexes. An example of such a success is the use of coastal wetland dollars by DOFAW, USFWS, and DU to enhance the Hamakua Canal Wetland.

Feral mallards, distinct from migrants that enter the State, have become a paramount problem for the Hawaiian duck (or Koloa). Recent evidence suggests that feral mallards on Oahu, the west coast of Big Island, and Kauai interbreed with the native Hawaiian duck. Recent genetic studies have shown that a high percentage of Oahu's Hawaiian ducks are hybrids. The Federal Endangered Species Act provides no protective status for hybrids. Feral mallards on Kauai and Big Island are mostly concentrated in urban or hotel ponds. A ban on mallard importation to Hawaii and the eradication of existing feral mallards are necessary.

We encourage Federal and State agencies to address problems with exotic mammalian populations on all islands. We especially urge these agencies to monitor Kauai so that mongoose do not enter the island. An interagency workshop for State and Federal biologists on wetland and waterbird management would be most timely for Hawaii.

Summary

Millions of dollars have been expended by conservation organizations and agencies to protect and preserve wetland habitats for endangered species, waterfowl, and other wetland wildlife. Exotic species often drastically reduce the biological capability of publicly purchased lands which, in effect, reduces the economic benefits that local communities receive from outdoor recreation-based activities and the quality of life that all enjoy from an abundant and ecologically diverse wetland ecosystem.

For more information, contact Eric Schenck, Manager Of Agricultural Policy, (202) 452–8824; Fritz Reid, Biologist, (916) 363–8257; or Roger Pederson, Regional Biologist, (612) 683–0441.

PREPARED STATEMENT OF THE U.S. POSTAL SERVICE

We appreciate the opportunity to submit testimony to the Senate Committee on Governmental Affairs, concerning the crisis of alien pest species invading Hawaii.

The dramatic nature of the alien pest invasion has been well documented. The Nature Conservancy of Hawaii has reported that since the 1970s, an average of 20 new alien invertebrates per year were recorded in Hawaii, with the potential of causing serious damage to the ecosystem and economy of the State. We believe that inter-agency coordination is the key to better control of alien pests, as suggested by two reports which studied the issue (*Harmful Non-Indigenous Species in the United States*, issued by the Office of Technology Assessment, September, 1993, and *The Alien Species Invasion in Hawaii: Background Study and Recommendations for Interagency Planning*, prepared by the Nature Conservancy of Hawaii and the Natural Resources Defense Council, July, 1992).

This task is made more difficult by the need to combat a multitude of species which attempt to enter Hawaii in a variety of ways. We are happy that we are able to continue our assistance to a cooperative, more comprehensive effort, through our prevention efforts involving First-Class Mail.

Our contribution to resolving this problem focuses on the problem of alien species-contaminated mail sent to Hawaii from the mainland United States. While it is recognized that the mail is a small part of the overall alien pest problem, we want to contribute our part toward a comprehensive solution. We believe that certain factors are essential for the protection program to function successfully.

Our primary concern is to develop an effective protection program, which does not impede postal operations nor violate Federal Fourth Amendment search requirements. Such a program must take into account that postal operations continue 24 hours per day, and minimize interference with mail processing operations.

Fourth Amendment protections governing search and seizure also must be preserved when dealing with First-Class Mail. The American people depend on the security and sanctity of the mail; and they rightly expect that their privacy in the mail, as in their homes, will be protected against unlawful governmental intrusion. This constitutional protection, requiring that a warrant be obtained for any nonconsensual search of domestic mail sealed against inspection, is part of the framework within which the Postal Service must operate. Proper search warrants, based upon a finding of probable cause that a prohibited item is contained in a piece of First-Class Mail, must be obtained in order to do a legal search. These requirements are met in the pilot program discussed below.

As has been suggested by State officials, an excellent model for the Hawaii protection program is the pilot program in the Honolulu Post Office which protects mail bound for the mainland United States from certain alien pests. This program was established on a trial basis following the passage of the Agricultural Quarantine Enforcement Act of 1988 (Public Law 100–574). Beginning in May, 1990, inspectors from the U.S. Department of Agriculture have been operating a program at the Honolulu Post Office involving First-Class Mail parcels. Items that match a "profile" of packages likely to contain prohibited agricultural products are set aside. A trained "sniffer" dog examines those packages, and Federal search warrants are obtained for any item that the dog identifies.

This program is a success story, in that it works without interfering with postal operations or legal restrictions on searches. Because of this success, it has been extended beyond its original time period. Recent data show that during July of 1993, a harvest month, the U.S. Department of Agriculture detained 125 outgoing packages. Dogs targeted 19 of these packages, for which search warrants were obtained. Seventeen packages contained contraband, including 25 contraband plants, with a total weight of 109 pounds. Fourteen civil penalties were assessed. The prohibited items were generally home-grown fruit such as mango, papaya, and litchi, or flowers sent to friends or relatives on the mainland. The numbers in January, 1994, were similar, with 110 parcels detained, 25 targeted by dogs, and 19 prohibited or restricted items located.

To protect the State of Hawaii from the crisis of alien pest introductions, Senator Akaka introduced the Alien Species Prevention and Enforcement Act, enacted in 1992 (Public Law 102–393). This act emphasized an inter-agency cooperative effort to achieve its protective goals. One of its aims was to establish a program which would protect Hawaii in a manner similar to the pilot program discussed above to intercept prohibited mail bound for the mainland United States. We believe that the approach taken by the act is appropriate and needful.

A program designed to parallel the existing pilot project in size and scope could have a potent deterrent effect and be successful, while complying with operational and legal requirements.

The pilot program also involved an education effort, to inform the people of Hawaii regarding the dangers presented by alien species introduction, and what items are nonmailable. This, too, could be a useful component of the program to protect Hawaii.

Since passage of the 1992 act, the Postal Service has been involved in the cooperative effort to implement this program. We believe that a program of the same type and scope as that in place to protect the mainland is both possible and desirable. It also seems likely that the key to the success of the program is to focus prevention efforts on a list of items which meet certain legal and logistical criteria. First, the items must be capable of being successfully "profiled." Under the current pilot program, for example, there are criteria to determine the likelihood that a package contains fruit. Items which meet the profile can be set aside for a dog to check. Second, it must be feasible to train the dogs to alert to the items on the list. For example, under the current program, the dogs can be trained to alert to fruit. These criteria make it possible to comply with Fourth Amendment search requirements.

Of the items which meet these two criteria, primary emphasis should be given to those items that are potentially most hazardous ecologically, and most harmful economically. The interdiction program also must follow the legal requirement not to delay the mail or subject it to damage.

In addition to the compilation of a targeted list of items, there are resource problems to be addressed. We understand that there are limited Federal personnel to work on the program to protect Hawaii, and have heard it suggested that State personnel be deputized to assist with the program. We believe that this is a workable idea, and would be willing to help ensure compliance with operational restrictions and legal requirements. As an example, we understand that a memorandum of understanding has been developed to allow for cooperation between the State of Hawaii, Department of Land and Natural Resources, and the U.S. Fish and Wildlife Service.

We look forward to working with other Federal and State agencies to make the Hawaii program, as it involves the mail, as effective as possible, while complying with legal restrictions and not inhibiting postal operations.

PREPARED STATEMENT OF NATIONAL AUDUBON SOCIETY

The National Audubon Society is pleased to be able to submit this written statement for the record of your hearing on the introduction of non-indigenous plant and animal species.

Exotic introductions are a challenge to our native flora and fauna and to species diversity in preserved ecosystems. The National Audubon Society owns or manages over 80 sanctuaries, several of which have been invaded by exotic species. In some cases exotic species are consuming much of the time and resources of management of the sanctuaries.

The species of exotics invading Audubon sanctuaries, purple loosestrife, leafy spurge, Kudzu, zebra mussel, Brazilian peppertree, and melaleuca, are currently established in the U.S., spreading to new areas, and destroying the integrity of native ecosystems and the organisms to which these ecosystems are home, food, and shelter. These invaders are major concerns to specific bird sanctuary managers as they are with a broader group of agriculturalists and farmers. Fortunately, with the exception of Kudzu, the exotic plants are being addressed by ongoing programs of biological control by the USDA making it possible for sanctuary managers to participate eventually in the implementation of such programs.

Biological control agents have been found, processed through quarantine protocol, and colonized for leafy spurge. These successful biological control agents need to be effectively dispersed over the extensive range of leafy spurge to gain its control. With purple loosestrife, three biological control agents have been tested, approved for release, and now the releases are being made and evaluated in selected sites. Likewise, biological control agents are being tested in quarantine for safe release against Brazilian peppertree and melaleuca. Pest management strategies are being developed for zebra mussel. It is not dear whether biological control will be a viable option for control of zebra mussel. Kudzu is not targeted presently for biological control, but it is recognized as a serious pest that might be suitable for biological control. Perhaps in the future it will be addressed with a long-term solution. Before such a project will be undertaken several issues have to be resolved. There has to be further assessment of the pest versus the beneficial value of Kudzu. Also, a concern that some related, native species might be jeopardized by importation of exotic biological control agents for Kudzu will have to be resolved scientifically.

It is unfortunate there are not more sustainable, environmentally acceptable controls available for exotic pests. The prevailing mind set has been to eradicate exotics with chemical warfare for over half a century. It is only recently that budgetary constraints have begun to impact all government programs raising questions as to their cost and effectiveness. These questions may bring about the climate necessary to foster alternative controls for exotics.

Although there were very successful biological control approaches for exotic pests in the past, little has been done for the past 2 decades. Such long-term, sustainable solutions require an investment today before we can expect payoffs in the future. Successful weed biological control projects take 8 to 10 years from inception. Without an investment, the solutions will never be available.

A practice such as biological control which encourages the introduction of yet more exotic organisms, even though they are beneficial, is a legitimate concern. The introduction of any exotic organism should be attempted only with great diligence and caution and only by specialists who have training in the conduct of biological control.

Biological control is not a solution for every pest situation, and it should be used only where appropriate. Biological control has provided the most spectacular, target-specific, and self-perpetuating control of some of our most injurious exotic species. It is especially appropriate for use against pests in managed ecosystems for which chemical controls and chemical eradication programs pose great threat or where, in many cases, these approaches are not economically or operationally feasible.

Increased concern

Commerce and Transport. Today's tourism and commerce is contributing to a continual movement of biota, plants, vertebrates, insects, bacteria, fungi, viruses, and others, around the globe. In 1988, there were over 32,000 interceptions of organisms in luggage and market products at U.S. borders by the USDA Animal and Plant Health Inspection Service. Best estimates are that these interceptions represent less that 50% of the biota being introduced inadvertently or purposefully. Containerized cargo on ships, trains, trucks, and planes, the rapid movement of cargo among these modes of transportation, and other changes in transport methods make it easier and cheaper to transport goods in a global economy. However, these changes make it even easier for exotic organisms to survive transit from one region to another. These changes in transport methods also make it more difficult to intercept exotic biota with governmental interdiction programs, since ports of entry no longer are coastal and centralized, but distributed inland and dispersed to where they are convenient to commerce. Containers often are shipped to the site of use before being opened.

The global movement of goods and biota today have increased the problem, but introduction of exotic biota has been practiced from the time of ancient European, Egyptian, and Asian trade, through the spread of European culture around the world since the 15th century. The European colonists often moved promising plant cultivars and livestock animals to their new worlds to "improve" their agriculture and shipped new world biota of potential value back to the homelands for potential economic gain, as evidence of the bounty of the new world.

Many products that have been transported to our country are important to us today. Products such as apples, cherries, peaches, peanuts, wheat, horses, cattle, swine, and sheep, are examples of introductions that have become naturalized and a part of our culture. On the other hand, many imports have been tragic. Some of the tragic imports indude many human diseases, small pox, tuberculosis, etc.; many agricultural pests, including Chestnut blight, leafy spurge, kudzu, Russian thistle, gypsy moth, fruit flies, africanized honey bee, boll weevil; and nuisances of the household and stored products, some cockroaches, et cetera.

Competitive advantage of successful invading exotic species

Some species are particularly suited to invading new habitats. Scientists categorized these species several decades ago and called them "weedy species". Most migrant plants have characteristics of weedy species. They have very high reproductive rates. They produce many seeds, most of which do not survive unless they find their way to locations of minimal competition. Weedy species often have seeds that are designed to be carried long distances from their home site either by the wind, water, on the hair or fur coats of animals or even in the digestive tracts of birds and other animals. Weedy species are good competitors, having extensive root systems that are very effective at extracting water and nutrients from the soil, they can spread expansively to shade other plants and to get their sunlight, they can give off toxic chemicals which repel or inhibit the growth of other plants, and they tolerate or are immune to attack of native microorganisms, insects, or vertebrate herbivores that have not yet adapted to their defenses.

This last attribute of invading exotic species, the fact that they usually have no natural enemies or antagonists yet attacking them in their new home, deserves special explanation, because one of the solutions exploits this situation. Exotic species that have been accidentally or purposefully introduced into this country, or by escape from experimentation, share one important characteristic: they lack the pathogens, predators, parasites, or competitors that are found naturally associated with them in their place of origin. All organisms have competitors and natural enemies that limit abundance and reproductive capacity. However, when a species is displaced from this place of origin and established in a place where it has never occurred, these competitors and natural enemies rarely accompany the new establishment. Consequently, this species which innately is good at colonizing, establishing, and distributing itself also has the added biological and ecological advantage of being free of living organisms that have evolved with it in its natural community of organisms and which can constrain its reproduction and growth.

Aspects of species without natural enemies and competitors

The Good. Our livestock animals, crops, and ornamental plants that were introduced from abroad and which we cherish and which do not cause harm have limited numbers of pests attacking them. Their natural pests were left behind and the only pests they have are those that have adapted to them or "adopted" them in their new home. For desirable species, this strategy actually works to our advantage. Citrus, cherries, apples, peanuts, wheat, grain sorghum, horses, cattle, sheep, and many other species are grown in the U.S. away from their natural environment. Many of the severe pests that threaten these species were left in the place of origin. Similarly, this happens in other countries. For example, sunflower, native to North America, can be grown in Russia with very few pests or diseases. Cassava native to South America, can be grown with few pests or diseases in Africa. This does not mean plants and animals in new places do not have pests because local species can evolve and adapt to exploit the presence of new resources to their reproductive advantage. However, this adaptation usually is a slow process; if it ever happens it usually takes decades or centuries.

The Bad. Exotic pests of our exotic livestock and crops get introduced into this country at later times. Codling moth was introduced from Asia and now is a serious pest of apples and other fruits in the western U.S. Cherry bark tortrix, recently became introduced from Asia and threatens cherry production in the U.S. The brown citrus aphid has made its way to just off the shores of Florida and carries with it severe strains of trestazia virus of citrus. Russian wheat aphid (introduced in 1987) and greenbug (introduced in 1865) both came from the middle east and have done severe damage to wheat. Subsequently, greenbug evolved in a host shift to attack grain sorghum. Our exotic crops and livestock are constantly in danger of reunification with old pests by accidental introductions.

Solutions

Solutions should seek to conserve our biodiversity, to protect agriculture, and to avoid human health problems. The solution for the control of these exotic biota are many faceted and depend upon the nature of the organism and the conditions of their establishment. The solutions involve either eradication or some environmentally sound way to suppress the species population or reduce it competitive and exclusionary advantage.

Eradication: Eradication is a normal and appropriate response when pests are first introduced or if they occur in limited discrete areas after colonization. Vertebrate species usually are easily eradicated if discovered before widespread distribution has occurred. Immediate and well designed eradication efforts have been used effectively to remove newly introduced species such as the Asian gypsy moth from the Pacific Northwest, Mediterranean fruit fly from Florida, and others. An eradication program has successfully removed the screw worm fly from the U.S. and appears to have the potential for removing the pest from all of North America.

Other eradication programs such as the Mediterranean fruit fly in California, the boll weevil in the U.S., Mexican fruit fly in California and Texas, citrus black fly, North American grasshoppers, gypsy moth, citrus canker have either been ultimately judged to be impractical and abandoned as outright failures, or have evolved into extended quasi-regulatory programs fostering heavy pesticide usage on an annual basis with no end in sight.

Population management: Eradication of exotic species is a relatively new approach to addressing this problem. Many exotic species gained entry into this country and became "naturalized" species. Their value often is a matter of judgment, a balance of views from many special interests. Some are beneficial and we have adjusted to the damaging effects of others. For example, horses are part of Americana, but boll

weevils, imported fire ants, European corn borers, chestnut blight, nutria, etc. now are accepted as part of our fauna and managed accordingly. The eradication program for imported fire ant was a failure, causing more damage than good. The eradication program against the Mediterranean fruit fly in California is a hotly debated issue; and success is highly improbable. On the other hand eradication of Mediterranean fruit fly in Florida was successful. A multimillion dollar eradication program being pursued for citrus blackfly in Florida and Texas in the 1970's was abandoned because the introduction of two microscopic, parasitic wasps from its site of origin provided complete biological control in both Florida and Texas.

Some exotic species that have become major agricultural pests have been managed by biological control. Typically, a biological control program is conducted only after it has been determined that the pest warrants control and that biological control is an appropriate choice of many possible approaches. Biological control is accomplished by first identifying the geographic source of the exotic pest, its host plant(s) or animal(s), and conducting scientific searches to find and select appropriate agents from its natural enemies. These species, *more exotic species*, are then imported according to proper protocol and safety testing to quarantine facilities where specialists do more work on host relationships, host specificity, purity from contamination by other species, and suitability for release. Upon completing these quarantine protocols, application is made for release permits. If permits are granted, the beneficial organism(s) is released into sites highly suited for establishment and spread. With appropriate care and study and with a little luck, the biological control agent establishes and perpetuates itself to provide suppression of the pest exotic species. Between 24 and 55% of these attempts have been successful and permanent control of the exotic pests has been accomplished in over 100 cases in the U.S. and over 350 cases worldwide. Of the species now invading Audubon sanctuaries, leafy spurge, purple loosestrife, Brazilian peppertree, and melaleuca are being addressed by biological control projects. The leafy spurge program appears to be a success with the program being limited now by effective distribution of the successful biological. Control agents to new sites. The purple loosestrife project is in a testing phase; exotic biological control agents have been evaluated in the laboratory and three species have been released into the environment for colonization.

Transition from Eradication to Management

There appears to be a point at which an exotic species is no longer threatening to become establish, but *is* established. At such a point in this introduction, colonization, adaptation, and dispersal continuum eradication programs become too expensive and too environmentally disruptive to be practically executed. This critical transition deserves special policy and budgetary attention. Once established population suppression and management programs become the only alternative.

The form of management should be ecologically based Integrated Pest Management (IPM) defined as a pest and disease population management system that makes maximum use of biological control agents and utilizes all suitable techniques of pest suppression in a manner that is compatible with the use of these biological agents and other techniques to maintain pest populations at levels below those causing economic injury. In the case of invading exotic organisms the IPM program should involve consideration of importation of the exotic pest's natural enemies and/or antagonists for its control. A sound biological control approach for control of exotics offers a successful solution for control of exotic pests, worldwide.

Biological Control

Biological control does not eradicate pests. It establishes a new population equilibrium level, which if fully successful, maintains the pest population below levels that cause concern or damage. This approach seeks to introduce in the pest's new environment one or more of its long evolved natural enemies or antagonists from the pest's original environment so that the pest again faces biological limits to its ability to increase and spread. The fact that introduced biological control agents depend solely upon their host(s), the exotic pest, for survival means that the abundance of the pest will limit the abundance of the biological control agent. Conversely, the biological control agent will limit the pest in accordance to its ability to locate and propagate on the pest. This circular, negative feedback system is self-limiting and self-perpetuating.

What Is Needed

Most programs targeted at exotic pests have involved exclusion, interdiction, research, action, and education programs of several agencies and institutions. In the past and even now, these various components have not been coordinated for the purposes of managing exotic pest invasions in a timely and scientifically sound manner. Conflicting demands of export market constraints, international and interstate quar-

antine of agricultural commodities, and the need to respond with urgency have not produced long-term solutions to the problems posed by exotic pests.

USDA needs to develop a coordinated, results oriented program that proactively addresses pest exclusion.

1) A more effective and proactive interdiction program.

a) The USDA should keep, and publish annually, records of port-of-entry interceptions.

b) The USDA should analyze the port-of-entry records periodically to determine the most common sources and routes of exotic pests and establish off-shore programs, and education and suppression programs (if they can be done effectively and safely) designed to minimize imports of exotic pests.

c) The USDA research and regulatory agencies should develop a list of pests that threaten U.S. agriculture and hold the greatest probability of inadvertent import.

2) Eradication programs should be initiated only when there are clear goals, specific criteria for success to be met, full cost accounting, and there is a plan for termination of the program.

a) These programs should be limited to 90 days from initiation at which time an evaluation is done by a team of research scientists appointed by the Secretary of Agriculture and the Administrator of EPA makes a determination of the program for:

i. success of eradication,

ii. nontarget impacts from the eradication,

iii. full cost of program in funds, resources and other commitments,

iv. indicators for the need to transition to management strategies,

v. justification to continue the eradication program.

3) There should be provided an automatic transition from an eradication program into an IPM program so as to minimize environmental and public health impacts from eradication programs.

4) USDA must separate the regulatory decisions from the operational eradication/management programs. Regulatory programs (exclusion, detection, and elimination of exotic pests of U.S. agriculture) and the short-term (less than 90 days) eradication programs currently are the responsibility of APHIS. The operational programs for combating exotic species that have entered this country and have been present for more than 90 days should be governed by a special exotics task force formed by the research agencies of USDA, the Forest Service, the Agricultural Research Service, and the Cooperative States Research Service in cooperation with the cooperating State Agricultural Experiment Stations.

All operational programs, induding biological control, IPM, eradication, and other applied research, methods and development, and "action" programs should be transferred to the most appropriate USDA or Department of Interior agencies.

5) A clear and specific regulatory policy in APHIS that facilitates the safe and effective use of biological control. The policy should at a minimum do the following:

a) Provide clear procedures and guidelines for application permits to import biological control agents.

b) Provide a level of oversight that is consistent with the relative risk associated with the regulated classes of organisms.

c) Provide a decision upon an application within 60 days.

d) Establish a process that may be targets for biological control with a system of arbitration among interested and concerned parties to minimize legal delays.

We hope this statement is helpful as the Committee reviews Federal policies regarding the prevention and control of alien species.

PREPARED STATEMENT OF PETER VITOUSEK

I write as one who was motivated to become a scientist in part by the effects of non-indigenous species (NIS) that I saw growing up in Hawaii, and now as a biologist who has worked extensively on NIS and their consequences. The recent Office of Technology Assessment report "Harmful Non-Indigenous Species in the United States" did an excellent job of identifying the scope of the problem represented by NIS—and the deficiencies in our legal framework for dealing with them, and the lack of the seriousness with which we have tackled them in the past. The Senate could make a fundamental contribution to the solution of this significant national and global concern.

I have worked on the effects of NIS on the functioning of whole ecosystems in natural areas of Hawaii (Hawaii Volcanoes National Park, and elsewhere). My colleagues and I have published a number of scientific papers that show unequivocally that invasion by fire tree (*Myrica faya*) changes the pathway of development and the final state of the new tropical forests and soils that develop following volcanic eruptions—the very process a park should protect—in addition to displacing indigenous Hawaiian species. Similarly, we have shown that invasion by molasses grass (*Melinis minutiflora*) and other non-indigenous grasses allows fires to spread in previously fire-resistant woodland—and thereby converts a diverse native ecosystem into highly flammable biological desert in which only molasses grass thrives. These and other consequences of NIS are dramatic in Hawaii—but they are far from unique there. Invasion of an area by NIS can fundamentally change the way it looks, works, and interacts with its surroundings.

I would go farther than the OTA report in one respect. It discussed (very well) the effects of global change on NIS. I believe that the ongoing explosion of biological invasions represents a significant global change in and of itself—one that hasn't captured the attention that global climate change has, but one that is already costly to biological diversity and to our economy (far more than is climate change, now or for some decades to come), and one that is close to irreversible in a sense that even climate change is not. The consequences of NIS are most dramatic—so far—in Hawaii and other islands, and areas that humans already have altered. However, the rest of the Nation has not escaped. Western rangelands and our freshwater systems have been altered substantially, and even the great eastern forests have suffered the loss or diminishment of species after species (chestnut, elm, beech, fir, and dogwood) as non-indigenous pests and diseases move in. The direct costs to farmers, ranchers, fishermen, and municipal water users run to billions of dollars a year, and the cost to our national biological heritage is incalculable.

The scope of the problem is large, and its control will ultimately be costly—but a great improvement in how we cope with NIS could be purchased relatively cheaply and highly cost-effectively. The States must cope with the local and regional features of the problem—but the Federal Government could do a great deal to interdict interstate and international movement of NIS by expanding the American Public Health Inspection Service, and the scope of its mandate. It is also clearly a Federal responsibility to control NIS on Federal land, one that the dedicated people in the field are close to overwhelmed by. Tens of million of dollars per year are needed for the National Parks system alone. Finally, changes in Federal laws and regulations could help a great deal. For example, regulating NIS by specifying which species may be brought into the U.S. rather than which may not would help. Without a serious effort, which means a serious commitment of funds, NIS will continue to degrade our national biological heritage—and directly cost us much more than any reasonable level of spending on their control.

PREPARED STATEMENT OF MS. MARY LOU McHUGH

Mr. Chairman and Members of the Committee:

Thank you for the opportunity to provide this statement summarizing the Department of Defense programs to prevent the introduction of non-indigenous species into the United States.

Background

Historically, the Department of Defense (DOD) has cooperated with the Federal Border Clearance agencies responsible for the prevention of the introduction of non-indigenous species into the United States. Under the supervision of the U.S. Department of Agriculture and the U.S. Customs Service advisors, DOD personnel have been conducting pre-shipment inspections of personnel and materiel leaving the overseas theaters. Although originally established to halt the flow of drugs and other contraband into the U.S. through military controlled transportation, the program has enforced all U.S. laws and regulations established by the border clearance agencies. In a similar manner, the overseas military postal system operates under the policies established by the U.S. Postal Service, which includes prohibitions on mailing plants and animals as specified by the U.S. Department of Agriculture.

The regulating U.S. border clearance agencies include the Department of Agriculture (for agricultural pests and dirt), the Department of Transportation and the Environmental Protection Agency, (privately owned vehicles), the Bureau of Alcohol, Tobacco, and Firearms (weapons), the U.S. Fish and Wildlife Service (endangered species), the U.S. Public Health Service (human disease and disease vectors), and the Immigration and Naturalization Service (immigrants). The DOD program was

established to meet the border clearance requirements and thereby facilitate movement of military cargo and personnel through U.S. ports of entry without unnecessary delay.

The Department of Defense does not establish U.S. entry requirements. It is DOD policy, however, to assist and cooperate with all Federal border clearance agencies in enforcing their laws and regulations.

The Federal Government, through the Plant Pest Act (Public Law 85–36) prohibits the introduction of any animal, plant, or materiel which is considered harmful to U.S. agriculture. Military vehicles, such as trucks or M1 Tanks, and other equipment which have been exposed to the elements or may be otherwise subject to infestation (e.g., Gypsy Moth eggs, Nematodes, etc.), are cleaned (subject to washdown operations) and inspected prior to shipment to the U.S. to ensure compliance with Department of Agriculture requirements.

Brown Tree Snake

In 1987, the Quarantine and Retrograde Cargo Committee of the Armed Forces Pest Management Board, requested the support of the DOD inspection program in preventing the spread of the Brown Tree Snake in military cargo from Guam. Working with the guidance of the U.S. Fish and Wildlife Service, in February, 1988 via a worldwide message, DOD outlined the impact of the Brown Tree Snake on Guam itself and the initial changes to the DOD inspection program that would be required to help stop the spread of the snake in the Western Pacific.

These changes included:

- 100 percent examination (inside and out) of all household goods, hold baggage, cargo shipment containers, and pallets prior to packing and loading.
- Sealing of shipping containers after cargo loading.
- Screening of drains and windows in all warehouses and storage facilities.
- Inspection of aircraft and vessels prior to debarkation.
- Removal of ground cover in which the snake could hide from around all transportation facilities.
- Development of snake traps.
- Daylight operations and loading vice night (since the snake is nocturnal).
- Comprehensive and continuous education of all personnel involved in the movement of personnel property, household goods, military cargo, as well as aircraft and vessels.

This initiative placed DOD in the forefront of the fight to confine the snake to Guam. Since February, 1988, DOD inspectors have been aggressively searching for the snake on military ships, cargo and aircraft.

DOD Policy

U.S. military forces may he required to deploy virtually anywhere in the world. Associated with this deployment requirement is the potential to inadvertently introduce exotic plants and animal pests when U.S. forces redeploy back to the U.S. Extensive washdown and inspection operations were established for both the Operation Desert Storm and Somalia redeployments.

Given this, DOD continues work with the government agencies responsible for establishing and enforcing U.S. Border Clearance laws and requirements. Current DOD procedures are contained in a tri-service regulation entitled "Quarantine Regulations of the Armed Forces." In response to inquiries regarding quarantine and customs procedures as related to the military, both with ships and aircraft movements of cargo to the U.S., the Armed Forces Pest Management Board has published a Technical Information Memorandum: *Operational Washdowns—Inspection and Cleaning Procedures* .

This manual provides guidance for conducting washdowns of equipment in response to U.S. Department of Agriculture and public health inspections that are required for all incoming ships, aircraft and equipment returning from overseas. The prime purpose of the washdowns is to prevent the introduction of exotic pests into the U.S. by establishing guidelines for regulatory control of pests.

Conclusion

DOD will continue to provide full cooperation to the U.S. border clearance agencies responsible for establishing requirements and procedures to prevent the introduction of exotic agricultural pests into the U.S. DOD vehicles, and other equipment which have been exposed to elements or otherwise subject to infestation, will continue to be subject to washdown operations or other cleaning as may be necessary prior to entry into the U.S. DOD aircraft and vessels will continue to be examined.

Although DOD has been a leader in the prevention of the introduction of alien species into the U.S., DOD does not establish policy to implement the public law.

Congress enacts public law and the U.S. border clearance agencies establish the policy and inspection requirements. DOD then complies within its capabilities and resources.

USDA Animal and Plant Health Inspection Service (APHIS) Responses to Questions About Non-Indigenous Species

1. In the absence of new legislation to consolidate plant protection statutes, how does APHIS intend to prevent the interstate spread of agricultural and non-agricultural weeds?

With or without new legislation to consolidate plant protection statutes, APHIS will implement a new weed policy in 1996. The weed policy document has already been developed and cleared by the Plant Protection and Quarantine Management Team. The policy is broken down into phase I and phase II. Phase I included interviews with APHIS officials, other USDA agencies, State departments of agriculture, and key stakeholders, such as universities, seed trade and professional seed and plant societies. The interviews identified the key issues related to weed policy and control. We are now developing phase II which is the Implementation Manual for Weed Policy. This policy is consistent with the existing regulations promulgated under the plant protection statutes as they apply to weeds and can be modified so that it is consistent with any legislation enacted in the future.

2. How could APHIS ensure that the Nation is less often surprised by new species and novel pathways of introduction?

APHIS operates a Cooperative Agricultural Pest Survey (CAPS) system that focuses on new pest detection. The computer database is designed to draw attention to new pests that are reported. CAPS provides for the timely collection, storage, processing, and distribution of significant plant pest and disease information for Federal agencies and State departments of agriculture. We believe that use of the system by all participants will lead to better early warning of the introduction of new pests into the United States.

Novel pathways of introduction frequently develop with new commercial enterprises, and entry of more countries into the global marketplace. APHIS' International Services provides an international perspective on trade and pest conditions abroad. We believe that adopting modern data management and communications systems is essential to define and analyze introduction pathways.

For 1995, APHIS has proposed legislation that would shift Agricultural Quarantine Inspection (AQI) user fees from appropriations to a reimbursable account. The authority requested would enable APHIS to keep pace with workload demands and cost increases on a timely basis. The improvements would include increased staffing, equipment, and an automated tracking system. These improvements also would enable APHIS to respond quickly to emergencies and unanticipated industry expansion.

3. Page 244 of the OTA report cites the finding that preliminary DNA analysis of Medflies trapped in California during the 1989 and 1991 infestations very likely did not come from Hawaii because they genetically resemble Medflies from Argentina and Guatemala.

Question. Do you agree with this assessment?

APHIS has taken the initiative to develop a comprehensive research program to develop DNA analysis technology to determine the origin of Medflies captured in California. Several research groups funded by APHIS and CDFA are examining a variety of methodologies. The work cited in the OTA report was based on *preliminary* data and indicated that specimens detected during 1989 and 1991 in California were more like those from Argentina and Guatemala than specimens from Hawaii. The data should not yet be interpreted to mean that the specimens intercepted in California did not originate from Hawaii. In contrast, another researcher, using a different methodology, has shown that specimens intercepted in California during 1992 are more similar to flies in Hawaii than those in Guatemala. Additional research to determine genetic markers and additional specimens from foreign sites are needed to clarify the situation. APHIS is continuing to fund research and has established a Medfly Germplasm Repository to encourage the exchange of specimens and information.

4. The OTA report states that the unwillingness by APHIS to see localized problems as national concerns has been a source of continuing tension between the agency and State departments of agriculture.

Question. What changes by the Congress would clarify APHIS' role and speed response?

There are several congressional actions that could be considered. Once cleared and transmitted to Congress, we believe APHIS' proposed legislative package that consolidates and streamlines our plant quarantine laws and animal quarantine laws will be favorably considered by Congress. These legislative proposals, often called the Consolidated Statutes, clarify and enhance APHIS' authority in a number of important ways that would define roles better and improve responses.

Question. What new legislation would be required to give additional funding and adequate authority to handle emergency infestations of damaging alien species?

Quick access to funds is a key element of success in pest eradication or control and we would be pleased to explore with Congress any new ideas for addressing difficult funding issues. In addition, changing our user fee authority to provide better access to funds for staffing at ports of entry would enhance exclusion activities. APHIS may consider requesting a larger appropriation for its contingency fund, which would allow access to emergency response resources more quickly.

5. Americans generally object to inspection delays of first class mail or luggage.

Question. How would the Department of Agriculture accomplish improved detection and quarantine efforts without total inspection of incoming luggage, cargo and mail to Hawaii?

Currently, inspections are conducted by screening luggage, cargo, and mail. Total inspection is not practical, so APHIS concentrates efforts on risk evaluation, maintaining data on pests, and continuously refining the information. An extremely helpful detection tool is our Beagle Brigade, which is comprised of specially trained dogs that detect meat and plant materials in passenger bags and belongings. The detector dogs have a success rate in excess of 80 percent and serve a dual purpose: they allow program effectiveness to improve, and serve as a constant reminder to travelers of the importance of our agricultural quarantine laws. Also, APHIS continues to effectively use X-ray machines for screening air passengers' baggage arriving at international airports. Improvements in our ongoing programs and the identification of the non-indigenous species of concern would aid APHIS' effort to prevent the spread of plant and animal diseases and pests into Hawaii.

6. APHIS failed to promptly respond to the 1987 Florida infestations of varroa mites in honey bee colonies, only to see the pest spread to 30 States by 1991.

Question. What are some of the mistakes that were made in the case of the varroa mite infestation, and what are the economic consequences if this problem continues?

APHIS was very aware of the varroa mite and its potential impact on agriculture. In 1982, as part of its routine program to detect exotic pests, APHIS conducted a nationwide survey for varroa mite. More than 200,000 bee samples from 44 States were examined. All samples were negative. In addition to this survey, each year State Apiary Inspectors examine thousands of honey bee colonies looking for honey bee pests and diseases. All of these inspections were negative until September 1987.

APHIS took immediate action to determine the extent of the infestation. Cooperative survey efforts resulted in the detection of varroa mites in a total of 66 counties in 9 States indicating the pest was already widespread.

APHIS worked continuously with its State cooperators and the affected industry to develop Federal regulations which would prevent the interstate spread of varroa mites. APHIS convened a varroa mite Negotiated Rulemaking Advisory Committee to help develop workable proposed Federal regulations. All attempts to provide Federal regulations for varroa mite proved to be unworkable because of the lack of a method to eliminate the mites in colonies.

When varroa mites were first detected, economic analyses indicated that varroa mites could cause a one-third drop in honey production and significant crop losses due to a decrease in honey bee pollination services. These loss estimates have now been greatly reduced due, in part, to cooperative efforts between Federal agencies and stakeholders in the honey bee industry and the development of safe pesticides that effectively deal with the varroa mite in managed colonies.

APHIS continues to work with the States to assist them in implementing the National Honey Bee Certification Plan developed by the National Association of State Departments of Agriculture (NASDA). APHIS also continues to work with its counterparts in Canada and Mexico to restore free trade in honey bees. We were successful in reopening the Canadian market to queen honey bees from Hawaii.

7. Amending the Federal Noxious Weed Act would seem to be a prudent choice for combating these non-indigenous plants. Congress could also require stricter screening for invasiveness, or could direct more funds to weed management on public lands.

Question. Please comment on how you would approach the solution, given these alternatives.

As funding becomes available, APHIS would be in a position to conduct risk assessments for a large number of weed species coming into the United States. The

risk assessments would provide us with the necessary information to determine if a specific weed is harmful. Research and development could provide for devitalizing or seed cleaning technology. These treatment alternatives could be used to rid products of weed contaminants. A large number of invasive weeds already plague millions of acres of public land throughout the United States and cause billions of dollars in damage. Funds could be used to eradicate some infestation of new invasive weed species recently discovered and prevent their dissemination to other parts of the United States. Also, we believe APHIS' proposed legislative package that consolidates and streamlines its plant quarantine laws will clarify and enhance APHIS' authority in a number of important ways in relation to noxious weeds.

APHIS is building a national infrastructure for monitoring and surveillance for both plants and animals. We are consolidating some line items into this function. Exotic, endemic, and emerging diseases, pests, and organisms will be detected by this system. Coordinated responses with States and other Federal agencies based on this surveillance system must be implemented based on this data.

Section 15 of the Federal Noxious Weed Act already provides sufficient direction to the Federal land management agencies for the prevention and control of noxious weeds. Section 1453 of the 1990 Farm Bill requires the Secretaries of Agriculture and the Interior to coordinate noxious weed activities for Federal land management agencies. A result of this coordination effort will be the establishment of a Federal inter-departmental committee on management of noxious weeds. The committee will include agencies from the Departments of Agriculture, Interior, Defense, and Transportation.

The Forest Service is also making administrative changes in its noxious weed regulations. The current noxious weed policy was published in the *Federal Register* in December 1993 to receive public comments. After analyzing these comments, a final policy will be issued that will reflect an ecological approach to noxious weed management.

The Administration's budget proposal for the Forest Service in fiscal year 1995 includes a 25 percent increase to $2.8 million in noxious weed control over the fiscal year 1994 budget. The Forest Service plans to use this increase in funding to initiate efforts to bring noxious weed infestations to acceptable levels. To do this, the Forest Service will be conducting more weed control activities, including surveys and contracting with county weed control districts.

In addition, there is $15 million in emergency pest suppression funds available from the fiscal year 1994 appropriations to meet the needs in excess of the amounts appropriated ($12.9 million) for Forest Pest Management Federal and Cooperative Lands Prevention and Suppression.

These funding increases for fiscal year 1995 reflect the Department of Agriculture's concern for noxious weed control and other exotic pests.

Finally, the Congress could direct Forest Service research to focus on providing new and more effective biological controls and a better understanding of ecological amplitudes and long-term effects of exotic species.

8. The OTA reports, "Federal methods and programs to identify risks of potentially harmful alien species have many shortcomings—including long response times. Procedures vary in stringency throughout APHIS, risks to nonagricultural areas are often ignored, and generally, new imports are presumed safe unless proven otherwise."

Question. Do you agree with this assessment?

APHIS' authority for regulating non-indigenous species has been limited to pests of plants. We have developed an expanded weed policy and are drafting non-indigenous species regulations within the framework of our current authorities. The proposed Consolidated Statutes should be a mechanism for Congress to expand APHIS' authority beyond the current limitations.

9. Preventing new introductions is often touted as the best line of defense against alien pests. However, aiming for a standard of "zero entry" has limited returns, especially when prevention efforts come at the expense of rapid response or essential long-term control.

Question. How will APHIS address current port inspection and quarantine methods to better counteract this invasion threat?

APHIS is currently evaluating pathways that could allow the introduction of Mediterranean fruit fly into the continental United States. Surveys are in progress for airline passenger baggage, international mail, and Federal Express. Additional surveys of maritime cargo, air cargo, passengers, and freight crossing the Canadian border are expected to begin in June 1994. These surveys involve intensive sampling of each pathway to develop statistically valid measures of risk associated with each pathway. The results of these surveys will be used to better focus inspection and quarantine methods currently used by Plant Protection and Quarantine. APHIS also

conducts preclearance inspections in foreign countries rather than at U.S. ports of entry to further reduce the risk of introducing plant pests into the United States. We anticipate growth in this type of inspection service.

10. Eradication of harmful alien species is often technically feasible but complicated, costly, and subjected to public opposition. In the future, an increased number of biologically based technologies will probably be available.

Question. Are current safeguards adequate for genetically engineered, biologically based technologies?

Yes. Based on experience since 1987, APHIS has issued approximately 519 permits for release into the environment at over 1,250 sites for 32 varieties of plants. Under the notification alternative we have authorized 495 introductions for release to proceed for corn, cotton, tomato, tobacco, potato, and soybean at 1,549 sites. These introductions have occurred without incident.

Thorough APHIS reviews of the introduction of genetically engineered organisms are conducted on an organism-specific basis. Engineered organisms for which plant pest or environmental impacts could be an issue are addressed by requiring that such organisms be either physically or biologically contained. Further, to ensure that vegetative material does not persist in the environment after a field test is conducted under permit, Plant Protection and Quarantine officials conduct site inspections to ensure that the person conducting the field test follows standard and supplemental permit conditions. It should also be noted that the regulations applicable to the introduction of genetically engineered organisms do not supersede regulations applicable to the introduction of non-engineered exotic organisms.

APHIS is drafting comprehensive regulations governing the introduction (importation, interstate movement, and release into the environment) of certain non-indigenous organisms. We believe these new regulations are necessary because the plant pest regulations under which the movement of certain non-indigenous organisms are currently regulated do not adequately address the introduction of non-indigenous organisms that may potentially be plant pests. The draft regulations would provide a means of screening non-indigenous organisms prior to their introduction to determine the potential plant pest risk associated with a particular introduction.

Question. How do we ensure species specificity, slow pest resistance, and prevent harm to nontarget organisms?

Applications for the introduction of organisms regulated by APHIS, such as plant pests and genetically engineered organisms, must include the identity of the organism to be introduced. If the information is not provided, the application is inadequate and is rejected.

Both APHIS and the Environmental Protection Agency are cognizant of the fact that pest resistance will develop rapidly to products such as *Bacillus thuringiensis* (Bt) if appropriate integrated pest management strategies are not utilized. Both agencies have discussed with applicants the necessity of developing resistance management strategies for genetically engineered plants containing products such as Bt.

For each permit that is issued we evaluate the potential environmental impacts of each release in an environmental assessment (EA). Each EA contains an evaluation of the range of impacts (including impacts on nontarget organisms as well as on threatened and endangered species) that might occur when all the relevant factors are considered including the biology of the modified and parental plant, site-specific information on the agro-ecosystem, the experimental protocol, and any additional conditions imposed by Federal and State authorities.

For species that are not genetically engineered, we believe the draft regulations for introduction of certain non-indigenous organisms will provide a process for thorough consideration of species specificity, pest resistance, and potential harm to nontarget organisms and the human environment before release of non-indigenous species into the environment.

11. Despite our best efforts, alien pests will no doubt continue to develop resistance to microbial and chemical pesticides. However, the strategy of ecological restoration shows promise for preventing or limiting the establishment or spread of some harmful non-indigenous species.

Question. Does the Department of Agriculture have any ongoing efforts to manage non-indigenous species using the ecological restoration approach?

"Ecological restoration" is the base strategy for most of APHIS' weed programs. Recognizing that eradication cannot be accomplished in most cases, we cooperate with other agencies, such as the Forest Service; to make the site resistant to extensive reinvasion by studying agricultural/grazing practices, reintroducing native plant species, and establishing biological control systems. We are also promoting the use of area-wide pest management, which is founded on the principle that pests are often more effectively controlled on an area or ecosystem basis than on a field-by-field or farm-by-farm basis.

In addition, the Forest Service, Extension Service, Agricultural Research Service, and Soil Conservation Service stress management practices that restore or maintain ecologically healthy ecosystems through programs such as Range Reform and Ecosystem Management. These management practices are the very basis of integrated pest management programs. Important methods for effective suppression actions are biological control and genetic resistance. Both the Agricultural Research Service and the Forest Service have research programs in these areas. These approaches can also be defined as ecological restoration because they strive to establish natural checks and balances within invaded ecosystems.

12. Domestic and international mail is a known pathway for the spread of harmful alien plants and agricultural pests. Many live organisms now are available through catalogue sales, and nurseries and aquatic plant dealers sell several federally listed noxious weeds through the mail. Congress recently passed a law specifically addressing this problem in Hawaii, the Allen Species Prevention and Enforcement Act, designed to allow the inspection of first class mail entering Hawaii.

Question. Recognizing that adherence to Federal and State laws that limit areas to which live organisms may be shipped is largely voluntary, is a similar postal inspection program warranted and feasible for all mail originating from outside the contiguous 48 States?

At this time, we believe a comprehensive postal inspection program is not practical for all mail originating from outside the contiguous 48 States moving into one State or area. A search warrant must be obtained prior to opening domestic first-class mail, but no such warrant requirement applies to the search of international mail.

International mail is sorted at concentrated collection points, thus providing an efficient use of inspectors and detectors to interdict prohibited plants and materials into all States. The same is true for mail leaving Hawaii, which is concentrated in Honolulu before shipment to the mainland.

Currently, we are working with the State of Hawaii to identify the specific pests and inspection protocols that can be appropriately included in a functional quarantine program. Due to the nature of the materials Hawaii is interested in excluding, the model developed for the mail inspection program to the mainland may not be applicable. We will continue to cooperate with the State and agencies involved to activate a postal inspection program for Hawaii. We seek to provide a postal inspection service that would provide protection from the highest risks.

13. How will the Forest Service's new policy of ecosystem management change its work related to NIS?

Ecosystem management recognizes that management goals and objectives pertaining just to resource output yields are not enough to ensure that the full range of ecosystem values and functions remain intact. This new approach aims at sustaining diverse, healthy, and productive ecosystems so that people may continue to benefit from their management goals and objectives that relate to the health and sustainability of ecosystems, and to the complex roles that the National forests and grasslands serve in the lives and livelihoods of Americans.

First and foremost, our professionals understand that an ecosystem management approach requires working with, not against, the dynamic processes that shape and sustain ecosystem health. Proper ecosystem management requires an understanding of the importance of the dynamic ecological systems that respond to perturbations of both natural origin and human origins, such as increased rate of introduction of exotic species. Biological diversity is crucial to ecosystem health. A key factor in determining the ability of systems to adapt to environment change is the quality and variety of genetic raw material contained in the systems life forms. Our goal is to maintain the composition, structure, and function critical to maintaining the ability of ecosystems to adapt to the rigors of the environment. The result is rich and complex ecosystems that are resilient to a variety of environmental stresses. An aggressive approach to understanding and managing the effects of invasive exotic plants is a critical factor in maintaining biological diversity.

14. Prevention appears to be the best approach in limiting introductions of alien pests, with environmental education as the key element. Still, little research has been done on why people bring illegal plants and animals into the country, or why they dump these harmful species outside their property.

Question. What recommendations do you have for educating our citizens on the dangers of alien species?

The most important aspect of an educational campaign is reaching a targeted audience with a specific message. To accomplish this, we involve the local media, (television, radio, and print) and use public service announcements and topical stories to increase the audience's awareness about the dangers of non-indigenous species. We also distribute brochures, guidelines for travelers, and fact sheets, signs in ports,

and work with the travel industry to keep travelers informed of Federal requirements.

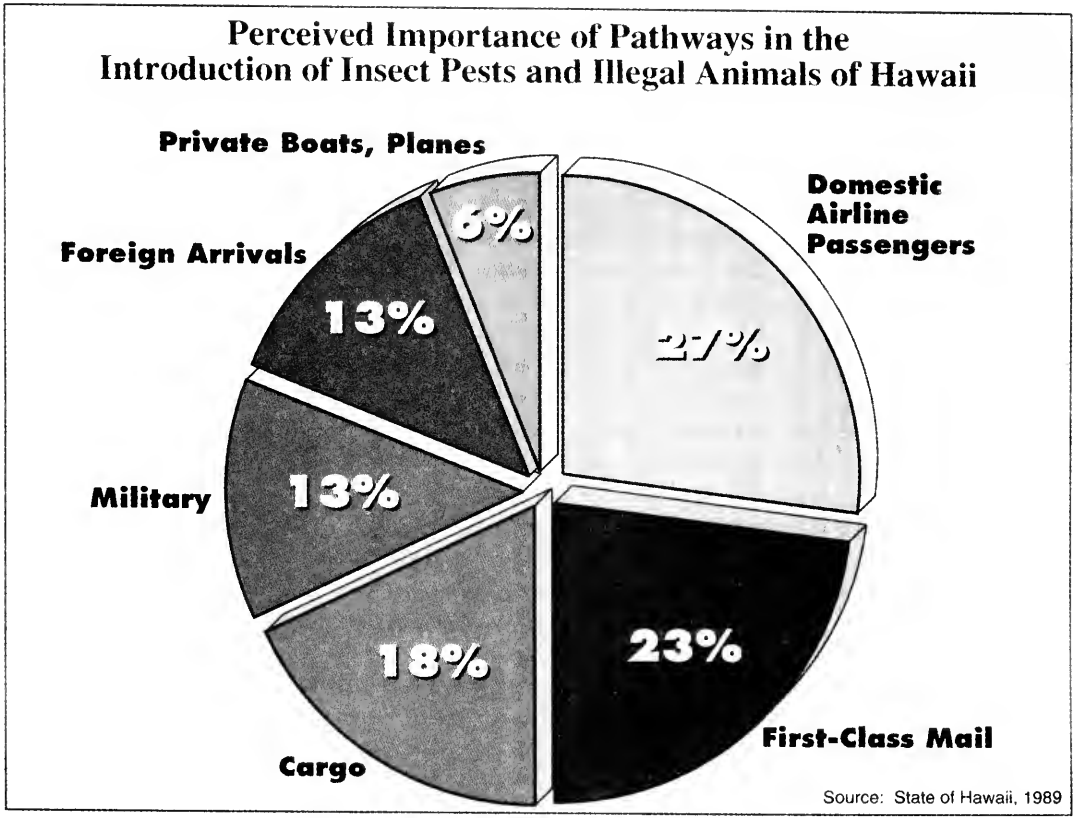
At international airports and ports of entry throughout the country, we have a number of mechanisms in place for educating international travelers. Inspection officers also inform travelers about the threat foreign pests and diseases pose to agriculture and the importance of adhering to agricultural quarantine regulations.

In addition to reaching travelers at airports, other ways for disseminating educational material are community meetings, press conferences, and the mail. Important information can be retained by people when they can associate a particular symbol or icon with a particular idea or action. For example, Smokey Bear has repeatedly said "only you can prevent forest fires." An image and message that go hand in hand. APHIS is pursuing the idea of developing an image and message centered on the Beagle Brigade and its effort to protect America's food supply and ecosystems from harmful non-indigenous species. This effort could simplify the message, yet emphasize the importance of how our mobile society can impact our food supply and environment.

The effort to inform the public should be a cooperative effort among all concerned parties, such as the agriculture industry, transportation industry, the States, research institutions, and universities. In this way, the message will be widely distributed and the responsibility shared.

Question. What new legislation would be required in order for APHIS to respond to new infestations of plants, animals and pathogens that are not currently subject to quarantine status?

Once cleared and transmitted to Congress, we believe APHIS' proposed legislative package that consolidates and streamlines our plant quarantine laws and animal quarantine laws will provide encompassing changes to our quarantine authority. The legislative proposals, often called the Consolidated Statutes, clarify and enhance APHIS' authority in a number of important ways that would clarify roles and improve responses.


Perceived Importance of Pathways in the Introduction of Insect Pests and Illegal Animals of Hawaii
Private Boats, Planes
6%
Domestic Airline Passengers
27%
Foreign Arrivals
13%
Military
13%
18%
Cargo
23%
First-Class Mail
Source: State of Hawaii, 1989

THE OUTDOOR CIRCLE
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February 11, 1994

The Honorable Daniel K. Akaka
United States Senate
720 Hart Senate Office Building
Washington, D.C. 20510-1103

Dear Senator Akaka:

The Outdoor Circle is increasingly concerned about the uncontrolled spread of Coccinia grandis, commonly known as ivy gourd. This virulent pest is growing out of control, particularly on the windward side of Oahu, and threatens to suffocate all trees and shrubs growing in its way. To see the disastrous effects of this blight, I recommend you view the Kapaa Quarry Road in Kailua. Extensive damage has occurred to the existing trees as a result of the spread of ivy gourd.

Knowing of your keen interest in Hawai`i's environment and your support of research through the National Biological Survey, we are appealing to you to direct available federal funding to the State of Hawai`i's Department of Agriculture. Researchers in our state desperately need the funds to find environmentally safe measures to combat ivy gourd.

Your support is very much appreciated. Thank you.

Sincerely

Mary Steiner

Mary Steiner
C.E.O.

FEDERAL AGENCIES WITH ALIEN SPECIES RESPONSIBILITY

USDA

- Animal and Plant Health Inspection Service
- Agricultural Marketing Service
- Agricultural Research Service
- Agricultural Stabilization and Conservation Service
- Cooperative State Research Service
- Foreign Agricultural Service
- Soil Conservation Service
- U.S. Forest Service

Department of the Interior

- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Fish and Wildlife Service
- National Biological Survey
- National Park Service

Department of Defense

- Directorate for Transportation Policy
- Deputy Under Secretary, Environmental Security
- Army Corps of Engineers

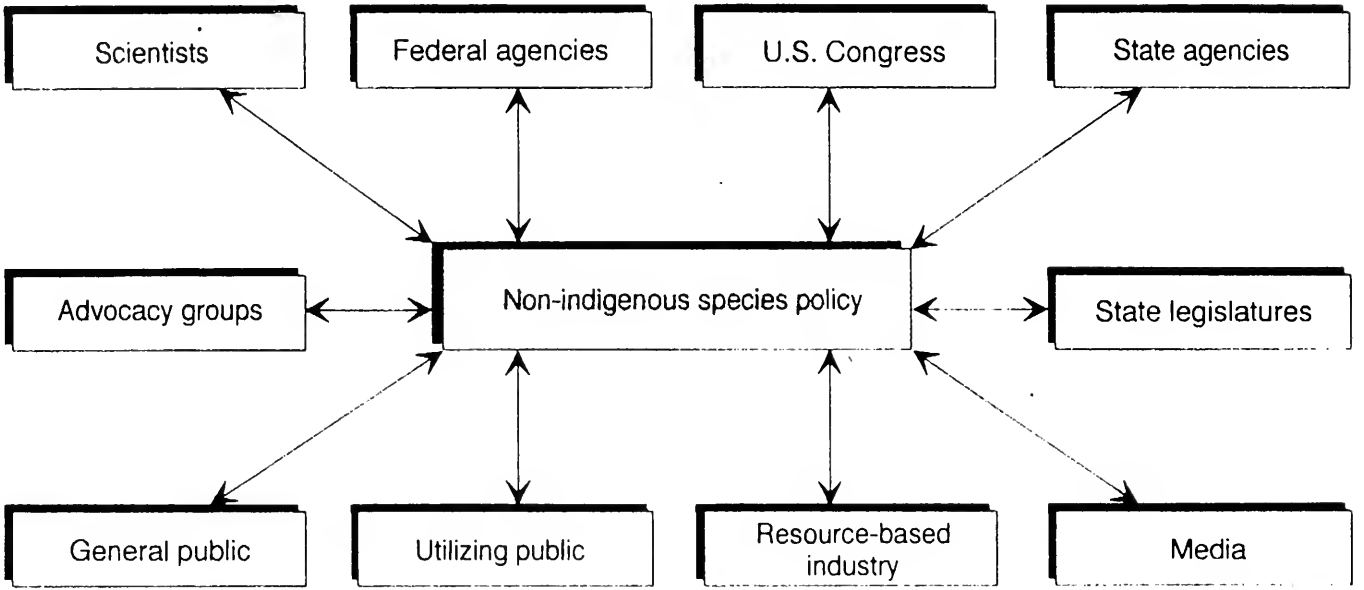
Other Agencies

- Department of Energy
- Drug Enforcement Agency
- Environmental Protection Agency
- National Oceanic and Atmospheric Administration
- U.S. Coast Guard
- U.S. Customs Service
- U.S. Public Health Service

Source: OTA Report, September 1993

species responsibility

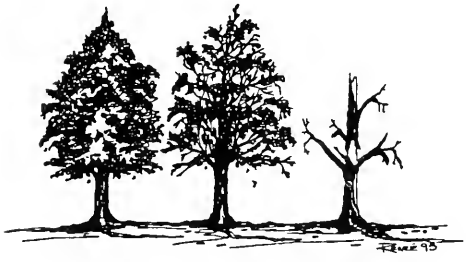
Figure 4-4—The Major Interests Involved in Shaping Non-Indigenous Species Policy



Source: OTA Report September, 1993

FADING FORESTS

North American Trees and the Threat of Exotic Pests



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NATURAL RESOURCES DEFENSE COUNCIL / JANUARY 1994

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About NRDC

NRDC is a non-profit environmental membership organization with more than 170,000 members and contributors nationwide. Since 1970, NRDC scientists and lawyers have been working to protect the world's natural resources and to improve the quality of the human environment. NRDC has offices in New York City, Washington, D.C., San Francisco, Los Angeles, and Honolulu.

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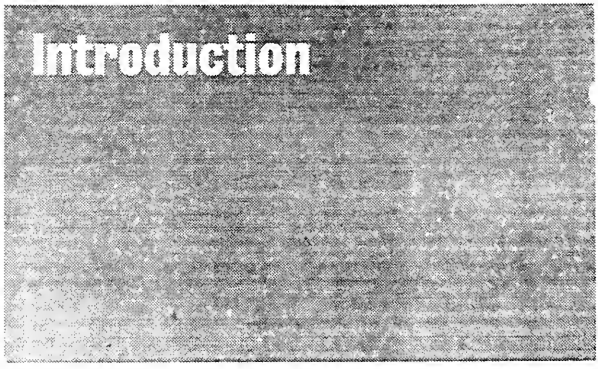
Preface

An intense debate currently rages over management of North American forests. Curiously, the impact of exotic (introduced or alien) pests on forest ecosystems has largely been ignored in the past, despite widespread damage. Already, numerous tree species are seriously affected. Furthermore, between 1991 and 1993, at least four new exotic pests have been discovered. Advocates of forest utilization, whether for consumptive or nonconsumptive use, need to recognize the potential threat of exotic pests to forest composition, health, and longevity. The interest in restoring the health of North American forests represents a common ground among contending interest and consumer groups.

This report documents the extensive impact that exotic organisms have had on North American forests by using examples of affected tree species. Economic and ecological consequences are presented. The mechanisms for prevention of exotic organisms entering the U.S. and control of existing exotic pests are discussed. Two United States Department of Agriculture (USDA) agencies are primarily responsible for pest prevention and pest control. The USDA Animal and Plant Health Inspection Service (APHIS) is responsible for inspection and, if necessary, quarantine or denial of entry, of animals and plants imported into this country. The responsibility for control of introduced pests, and associated research, has been shifted to the USDA Forest Service and cooperating state agencies and universities.

In addition, this report relates the current challenges and problems of importing pest-free wood materials, particularly from Siberia, New Zealand, and Chile. An increase in raw wood importations will raise the probability of new, exotic pest infestations. At present, the USDA-APHIS is considering alternatives in pest mitigation procedures to exclude or minimize exotic pest introductions. We recommend that APHIS develop and apply reasonable, uniform mitigation procedures for different wood materials, *e.g.*, chips or logs, regardless of the species or country of origin. Development of such procedures should have input from all forest user groups.

Finally, this report suggests that a comprehensive national pest management program needs to be developed within the framework of existing agencies. The growing number of exotic pests and the corresponding damage to the ecosystem dictate that a nationwide strategy be devised. Current budgetary levels will not support all facets of a comprehensive program, so additional funding will be required. The burden of such funding should be borne by all user groups, rather than only those groups that generate revenue from wood utilization.



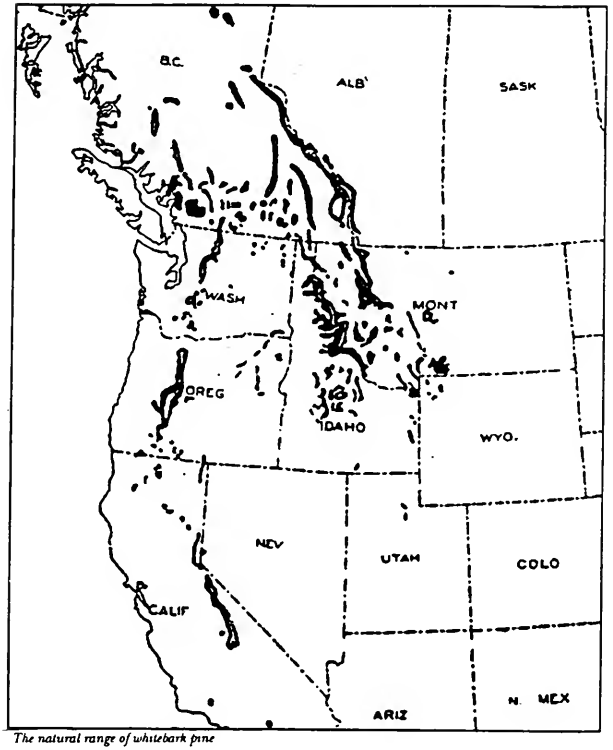
The current debate over forest land use has involved citizen groups, local, state, and federal governments, and private companies. Land uses advocated range from complete, permanent preservation to various utilization options, including timber harvesting by clearcutting. From the broad constituency involved in environmental issues, it is evident that wise stewardship of natural resources is very important to most Americans. Basic American values, such as landowner rights, national heritage, right-to-work, and appreciation of natural beauty, are reflected in articles, debates, and other communications on North America's environment. Confrontations between groups having consumptive versus nonconsumptive viewpoints regularly occur, both in personal exchanges and in courtrooms. In contrast, the maintenance of forest health is one particular area where there is a general agreement among all concerned citizens. Regardless of how the forest is used, a forest in poor health—*e.g.*, a forest with a high proportion of dead and declining trees—is relatively unproductive. Declining forests have relatively low production rates of timber and mast (nuts, fruits, and berries), which affect wildlife populations, and are not aesthetically pleasing.

Many reasons explain unhealthy forests. Some problems are related to the increasing industrialization of the world. Other problems are caused by biological agents or "pests" that feed upon forest plant species. A widespread pest infestation, *e.g.*, gypsy moth (*Lymantria dispar*),* can permanently alter a forest in terms of plant and animal species composition. Forest-dwelling animals, as well as forest vegetation, are affected by pest-caused devastation. In the eastern forests, the loss of American chestnut (*Castanea dentata*) to an exotic fungal blight probably drastically reduced populations of black bears and turkeys (Pelton, personal communication). Reductions in whitebark pine (*Pinus albicaulis*) populations due to another exotic fungus have impacted grizzly bear and Clark's nutcracker populations in western forests (Kendall and Arno 1989).

Interestingly, many publications on forest problems and history do not mention or emphasize the destruction caused by forest pests (MacCleery 1992, USDA Forest

*Appendices B, C, and D provide the common and Latin names of species mentioned in this report.

Service 1984). The effects of forest fire, air pollution, logging, farming, grazing, and homesteading are discussed, yet devastation from major pest infestations is virtually ignored. Pests have altered entire forest ecosystems in eastern North America and have had a major impact on western forests in certain localities. Exotic pests from other continents have proven to be more destructive than endemic insects and diseases. Native insects, other arthropods, and fungi are part of the natural forest ecosystem. Native forest trees have evolved with native pests, and have developed defense mechanisms. Over the long term, these mechanisms keep the essential balance of the natural ecosystem intact. However, when alien or exotic insects, arachnids, saprophytic plants, fungi, and diseases are introduced into the forest, extensive damage or mortality can occur. Natural controls for introduced pests are usually absent. Native trees, without a history of natural interaction with exotic pests, often have little or no resistance mechanisms. As a result, native species can be seriously damaged or eventually eliminated.



The natural range of whitebark pine

Exotic insects and diseases have damaged North American forests for more than 100 years (*cf.* Crandall *et al.* 1945). In a recent forest health survey for the Northeast, Burkman *et al.* (1993) found that forest types covering more than 60 percent of the total forested area (which covers about 165 million acres) have been seriously damaged by introduced insects or pathogens. While the true economic costs of forest damage caused by all forest pests are difficult to calculate, lost timber revenue alone amounts to $2 billion annually (Pimentel 1986). The impact on industries that are connected with recreational forest use is more difficult to estimate. Industries associated with hiking, hunting, fishing, and other outdoor activities can be seriously affected if the forest is no longer suitable for a particular recreational activity. The ecological cost, in terms of an altered forest ecosystem, cannot be adequately measured. According to Ledig (1992), "Introduction of exotic diseases, insects, mammalian herbivores, and competing vegetation has had the best-documented effects on genetic diversity [of forest ecosystems], reducing both species diversity and intraspecific diversity." Their impact has been greater than that of other, more widely recognized, human-caused factors, including forest fragmentation, changed demographic structure, altered habitat, pollution, and favoring of certain "domesticated" species of trees. Exotic pests have virtually eliminated important species such as the American chestnut and American elm (*Ulmus americana*) as viable components of eastern forests and have radically altered the eastern forest ecosystem (Ledig 1992).

The majority of exotic forest pests in North America have been introduced on imported nursery stock or logs. Past problems with imported pests resulted in the formation of the Animal and Plant Health Inspection Service (APHIS) in the United States Department of Agriculture (USDA). Strict regulations on importation of nursery stock were implemented decades ago (Plant Quarantine Act 1912).* Until recently, however, there were no specific timber import regulations to insure protection against exotic pest introduction. APHIS relied on visual inspection of logs entering U.S. ports to detect insects and pathogens. Importers were required to eliminate any pests found prior to bringing the logs into the country for processing. This policy reflected the fact that log shipments usually were relatively small or from countries considered to be substantially free from pests that could damage American forests, *e.g.*, countries with a tropical climate. Now, however, the reduction of harvesting in U.S. National Forests and increasing controversy about logging in the United States, especially in old-growth forests of the Pacific coast, have created an interest in importing large quantities of logs from Siberia, New Zealand, Chile, and other countries with similar climates and forest types as in North America.

In the context of this paper, the most important question raised by such proposals is the possibility of introducing exotic pests into North America. Although USDA has begun to take steps to control or respond to the introduction of alien pests, their efforts to date are inadequate in the face of this serious threat. Pests could have extremely high economic and ecological costs if they became established in the widespread coniferous forest ecosystems of the American west. In 1961, Boyce predicted that "[a] virulent introduced parasite is infinitely more destructive to pure than to mixed stands, . . . no more potentially dangerous situation for disaster can be imagined than t' e extensive pure Douglas-fir forests of the Pacific Northwest or the far-flung pure stands of ponderosa pine and lodgepole pine in other parts of the West." Unfortunately, this prediction has been realized, as western forests are currently threatened by exotic pests such as the Asian gypsy moth. Some examples of past and current exotic pest devastations are listed below to illustrate the magnitude of exotic pest problems.

* See Appendix A for a summary of statutes governing exclusion and control of alien forest pest species.

Chapter 1: Examples of Exotic Pest Devastations in North America

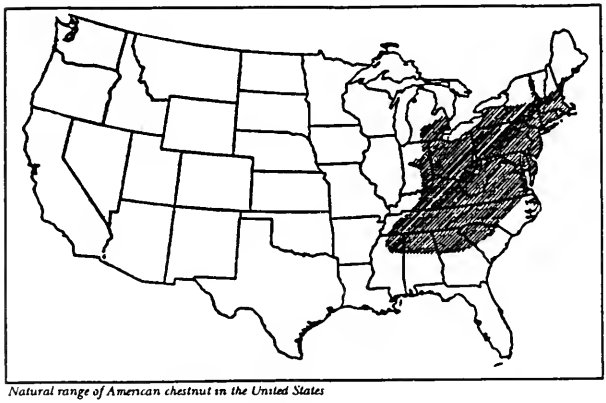
American Chestnut Blight

The American chestnut was once the most important hardwood species in the eastern U.S. The species was found in vast stands from Maine to Georgia before the turn of the twentieth century, accounting for one-quarter of all the standing timber in eastern forests (USDA Forest Service 1991b). In 1904, an introduced fungal disease, *Cryphonectria* (= *Endothia*) *parasitica*, changed the species composition of eastern North American forests. The disease was first observed on dying American chestnut trees in the Bronx Zoological Gardens. Introduced to North America in a shipment of Asian chestnut nursery stock, chestnut blight spread throughout eastern hardwood forests at a rate of 24 miles per year (National Academy of Sciences 1975). By the 1950s, virtually all mature American chestnuts had succumbed to the disease. American chestnut is now a minor understory component, existing as sprouts from old stumps and root systems (*cf.* Burnham *et al.* 1986).

The species provided timber, food, and tannin that were important to early European settlers. In recent years, the emphasis on utilization of American chestnut for wood products has overshadowed the importance of the species in wildlife food chains (Schlarbaum 1989). Annually, the tree would produce large crops of hard mast, unlike the oaks, hickories, and other trees that have replaced the chestnut. It is not known exactly how critical American chestnut was to wildlife populations. American wildlife biology was not well developed as a science in the late 1800s and early 1900s. No surveys were conducted before or during the demise of the chestnut that could document the impact on animal species (Pelton, personal communication). In addition, simultaneous widespread timber harvesting in eastern forests complicates efforts to assess the importance of chestnut to wildlife. However, historical accounts and old photographs clearly indicate that wildlife was much more abundant before the blight decimated the species.

Different approaches have been used in attempts to develop a blight-resistant American chestnut for eastern forests. These approaches include breeding within the species, hybridization with blight-resistant Asian hybrids and use of hypovirulent

strains of the fungus (Diller and Clapper 1965, 1969; Thor 1976). Currently, a promising development involves the genetic engineering of the virus that induces hypovirulence (Choi and Nuss 1992). Regardless of the approach, the end result will be a tree that is resistant, not immune, to the chestnut blight. Resistant trees may be able to survive in present-day forest situations, but could be more susceptible to secondary attack from other pests.



Natural range of American chestnut in the United States

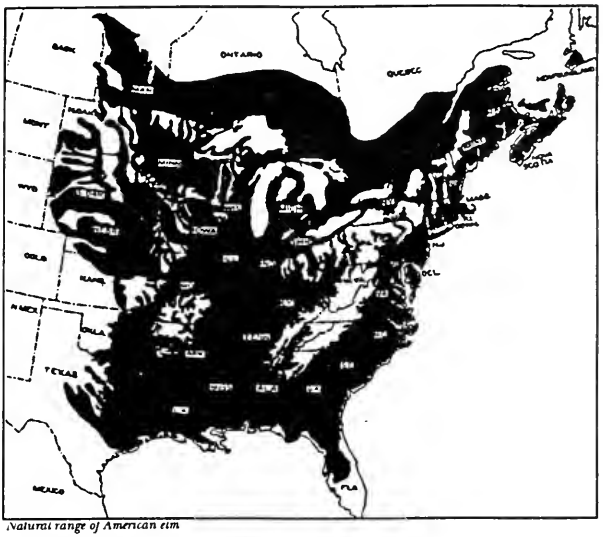
A chestnut in North American forests will have to contend with several exotic pests aside from chestnut blight. There is good evidence that an exotic fungus, *Phytophthora annamomi*, had infested southern populations of American chestnut and Allegheny chinkapin (*Castanea pumilla*) as early as 1824 (Crandall *et al.* 1945). The fungus attacks the roots and causes mortality or decline. Infestations by the chestnut gall wasp (*Dryocosmus kuriphilus*) were first reported in 1974 (Payne *et al.* 1975). Initially, this insect infested *Castanea* species in Georgia and gradually spread to adjacent states. Chestnut gall wasp larvae feed upon bud and flower tissue forming a characteristic gall. Mortality can occur with severe infestations.

Dutch Elm Disease

Dutch elm disease is the most devastating shade tree disease in the U.S. (Karnosky 1979). The American elm was once the primary ornamental tree in eastern and midwestern cities. The species was noted for fast growth and a vase-shaped form that made it an ideal choice for shading houses and streets. From the eastern forests, American elm provided lumber for boat building, cooperage, furniture, and agricultural implements. After 1930, however, use of American elm in urban landscapes and as a forest product dramatically decreased due to an exotic fungal disease. Dutch elm disease was first recorded in Cleveland, Ohio in 1930, and rapidly spread throughout eastern North America from three different infestation centers (May 1930; *cf.* Stipes and Campana 1981). The disease, caused by an introduced fungus, *Ophiostoma* (= *Ceratocystis*) *ulmi*, was brought into the country on different shipments of unpeeled raw veneer logs from Europe (USDA Forest Service 1991b). By 1977, the disease had spread to most of the contiguous 48 states. In the Northeast U.S. alone, 75 percent of the elms had died by 1979 (USDA Forest Service 1991b). Cities with large elm popu-

lations have suffered more than an aesthetic loss. The removal of dead and dying elms has cost up to an estimated $100 million per year nationwide (Mazzone and Peacock 1985). The disease has also virtually eliminated American elm as a timber species (Burkman *et al.* 1993). The five other species of native elms, *e.g.*, red or slippery elm (*Ulmus rubra*), are also vulnerable to infestation, but appear to have more resistance. Since arriving in America, the disease has evolved more aggressive strains which now are adding to the threat in Europe as well (USDA Forest Service 1991b).

Fungal infection usually occurs in wounds made by insect vectors and may be lethal in a small tree within a single year. Dual efforts have been made to control the disease, targeting the fungus and its primary vector, the introduced European elm bark beetle (*Scolytus multistriatus*). The removal of dead and dying elms and any dead wood left on the ground is essential to an effective long-term control program. This approach is feasible only in urban plantings, due to the expense of removal of the dead materials. Unfortunately, the disease also can be spread by root grafts between healthy and infected trees, which was particularly devastating to urban street plantings of American elms. Efforts to prevent spread of the disease by root grafts are usually frustrated by transmission of the disease by beetles (Swank and Smith, personal communication). Pesticides and fungicides have been used only in urban settings and have had variable success in preventing the disease or arresting existing infestation.



Natural range of American elm

Hybridization between American elm and disease-resistant Asian elms has been prevented by differences in chromosome numbers (Dermen and May 1966). Intraspecific and interspecific hybridizations have been made among selections of resistant Asian species and among American species (Townsend and Santamour 1993). Over 20 pure

American elm clones have been identified with good resistance to *O. ulmi*, and a number of hybrid elms and Asian selections have been released for urban plantings. Evaluations of resistant American elms in forest settings have not yet been conducted.

Gypsy Moth

The European gypsy moth has the broadest host range of all exotic pests in North America. The larval stage (caterpillar) defoliates a wide variety of woody plants, although it prefers hardwood trees. Oak species, which have dominated upland forests since the chestnut blight epidemic, are a preferred food source. Understory species important for mast production, *e.g.*, hazelnut, serviceberry, and hawthorn, are also favored food of gypsy moth larvae (*cf.* Gottschalk 1993). When preferred food sources are not available, older larvae feed on a variety of other woody plants including coniferous species of pine and spruce, arbor-vitae, and hemlock.

The insect was deliberately imported in 1869 to the U.S. in an attempt to establish a domestic silk industry. Gypsy moth was first observed as a forest pest in Massachusetts within 10 years of the original importation date. The pest has slowly spread throughout the northeastern states in subsequent years. By 1991, gypsy moth had infested 200,000 square miles of the Northeast, with additional outbreaks in North Carolina, Tennessee, Arkansas, Ohio, Michigan, and Wisconsin. Infestations of gypsy moth have also been reported in Washington, Oregon, California, and British Columbia, as well as in the Rocky Mountain states.

Gypsy moth infestations are cyclical. In 1978, 643,600 acres were defoliated, but in 1981, defoliation affected 12.9 million acres. An estimated 125 million acres were infested nationwide in 1991, of which 4.1 million acres (3 percent) were defoliated (Burkman *et al.* 1993). On the advancing front, the moth is perpetually at high population levels (USDA Forest Service 1991b).

Defoliation induces trees to drain energy reserves in attempting to refoliate. A healthy tree can usually withstand several consecutive defoliations of greater than 50 percent. Extensive feeding by gypsy moth larvae affects timber and recreational industries and alters the complexion of existing ecosystems. Mortality from defoliation can be as high as 90 percent where gypsy moth populations are at an epidemic level (Herrick and Gansner 1987). Although defoliation may not always result in tree mortality, diameter and volume growth will decline (Baker 1941, Twery 1987) and wood quality can be affected (Twery 1990).

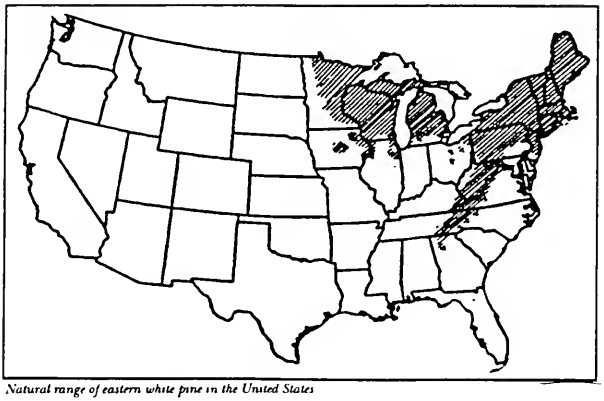
Gypsy moth defoliation will alter the species composition of the flora and fauna in a forest ecosystem by causing more nutritional resources to reach the remaining trees and plants in the over- and understory (Allen and Bowersox 1989). A change in the composition of plant species often affects certain wildlife populations and ultimately wildlife food chains. Water yield and quality in forest rivers, streams, ponds and lakes can be affected by gypsy moth activities. Water yield within a watershed increases after defoliation (Corbett and Lynch 1987). The decomposition of additional detritus on the forest floor increases the amount of nitrogen and other nutrients entering a water system and can alter water quality (Swank *et al.* 1981).

Gypsy moth infestations have an adverse influence on recreational use and associated industries. Alterations in plant and animal populations and water quality will have an influence on forest use for hunting and fishing. Heavy defoliation will reduce the aesthetic quality of the forest as a whole (Hollenhorst *et al.* 1993) and can result in a 20 percent reduction in recreational use in the infested area (Goebl 1987).

Various approaches have been used to control gypsy moth infestations. Pesticide spraying and silvicultural treatments have proven to be effective in controlling or minimizing gypsy moth damage, but have not stopped the spread of the pest into new areas. The Forest Service spent approximately $10.6 million on gypsy moth suppression and eradication efforts in fiscal year 1993. It is currently employing biotechnological methods to engineer more effective control agents to curtail the gypsy moth. Although the gypsy moth has encountered many native North American enemies, native predators and parasites have not been able to stop the spread of infestations. Naturally occurring *nuclear polyhedrosis* virus (NPV) is specific to the gypsy moth and has proved devastating to its survival. Unfortunately, the specific NPV has relatively limited natural occurrence. A solution containing the virus has been developed into a spray and is being tested under operational conditions (Cunningham *et al.* 1993). Over 50 exotic parasites and predators have been released over the years to control the pest (Burgess and Crossman 1929, Campbell 1975, Drost and Carde 1992). In 1989, an exotic fungus, *Entomophaga maimaiga*, caused high mortality in gypsy moths in New England (Andreadis and Weseloh 1990, Hajek et al. 1990). This fungus was originally introduced to control the gypsy moth in 1920, but previously has not had a significant impact. Research is currently being conducted to examine the efficacy of this fungus as a biological control agent (Hajek and Roberts 1992, Weseloh and Andreadis 1992).

White Pine Blister Rust

White pine blister rust is a disease that infests five needle pines (*Pinus* subgenus *Strobus*) throughout North America. The disease is caused by an exotic fungus, *Cronartium ribicola*, that was introduced to the continent on imported nursery stock in three separate locations: Kansas (1892), eastern Canada (1906), and western Canada (1921) (Mielke 1938, *cf.* Garrett 1986). From eastern Canada, it quickly spread



Natural range of eastern white pine in the United States

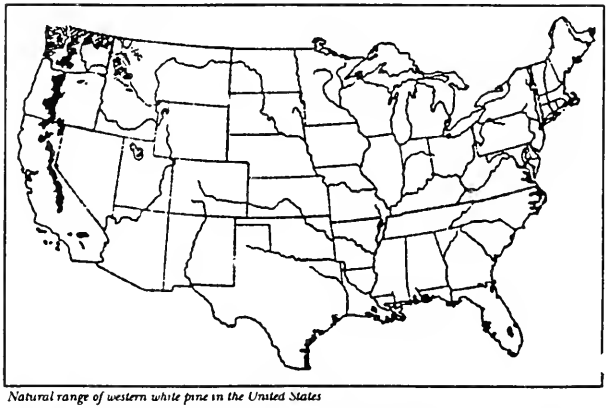
throughout eastern white pine (*Pinus strobus*) populations in the Northeast and Great Lakes region, followed by southward migration to high-elevation populations in North Carolina. In the Pacific Northwest, the disease spread throughout the ranges of its host trees, moving southward through California and into New Mexico (USDA Forest Service 1991b). Western white (*P. monticola*), sugar (*P. lambertiana*), whitebark

(*P. albicaulis*), southwestern white (*P. strobiliformis*), and bristlecone (*P. aristata*) pines are subject to infestation from this pathogen (Hoff and Hagle 1989).

Damage to eastern white pine has been comparatively less than damage to western white pine populations. The majority of eastern white pines grow in low-rust-hazard areas. In addition, the species is less susceptible to blister rust than western white pine (Bingham 1983). Western white pine stands can have as high as 94 percent mortality caused by the disease (Hirt 1948).

Different approaches have been utilized to control blister rust. The alternate hosts for *Cronartium ribicola* are species in the genus *Ribes*, *e.g.*, gooseberry, and blister rust control prescriptions have recommended the removal or eradication of *Ribes* bushes since the early 1900s. This practice continues in eastern North America, as *Ribes* removal has been shown to be a successful control mechanism in high-rust-hazard areas (Ostrofsky *et al.* 1988). In the western forests of Washington, Idaho, Montana, and Wyoming, almost 470 million *Ribes* bushes were removed from 1923 to 1965 (Hoff and Hagle 1989). This practice was discontinued, however, due to the limited and, often, absence of success in controlling blister rust. Chemical control using antibiotics was tried briefly, but was abandoned after limited success (*cf.* Bingham 1983).

The damage to western white pine populations was so extensive that operational planting of the species had been generally discontinued by 1968 (Ketcham *et al.* 1968). However, planting of western white pine has resumed using blister rust-resistant seedlings. Forest geneticists identified resistant trees in natural populations of western white pine, as well as other white pine species, and instituted screening/breeding programs (Riker *et al.* 1943, Bingham 1983). Genetic resistance to blister rust was found to differ among species (*cf.* Garrett 1986). Blister rust resistance is polygenic in eastern white pine, controlled by a single dominant gene in sugar pine, and at least two separate, recessive genes confer resistance in western white pine. Tree improvement programs have developed seed orchards for eastern and western white pines that produce seed with blister rust resistance.



Natural range of western white pine in the United States

Most of the five needle pine species are harvested commercially, particularly eastern white and western white pines. These two species are particularly valuable in forest ecosystems, as they often dominate forest stands over significant areas within their respective ranges (USDA Forest Service 1991b). Other species of white pine are not commercially important, but occupy critical ecological niches. Some white pines produce large seeds that are extremely nutritious and important in wildlife food chains. For example, whitebark pine seeds in the Rocky Mountains serve as a major food source for grizzly bear, black bear, red squirrels, and Clark's nutcracker (Kendall and Arno 1989).

Balsam Woolly Adelgid

True firs of the genus *Abies* in North America are attacked by the balsam woolly adelgid (*Adelges piceae*). The adelgid was introduced into New England in 1908 on European nursery stock (Koünsky 1916). The adelgid can cause physical damage by feeding, although chemically induced injury is the major cause of mortality. The salivary secretions of the adelgid change the balance of growth hormones and inhibitors and cause abnormal development of tissues in trees (Balch *et al.* 1964). The tissue is killed by a combination of factors associated with salivary secretions (*cf.* Hay 1978) and the infected tree can die within 2-7 years (Johnson 1980).

In the East, the balsam fir (*Abies balsamea*) is infested from northern New York into the Canadian Maritime Provinces and the Gaspe region of Quebec (Mitchell *et al.* 1970). Severe damage of balsam fir populations can occasionally occur. West coast fir populations became infested in approximately 1928 from a separate European source (Annand 1928). All western fir species have been infested, to varying degrees, with the possible exception of the unique bristlecone fir (*Abies bracteata*) (*vide* Hay 1978). As in eastern North America, damage to western fir species can be extensive.

The eastern infestation has spread south, along the Appalachian mountains. The northern bracted balsam fir (*Abies balsamea* var. *phanerolepsis*) has been almost eliminated by adelgid infestation. This variety of balsam fir has a very limited distribution and was restricted to two mountaintops in northern Virginia (Langdon, personal communication). Presently the only mature population covers less than one acre. Mature populations of Fraser fir (*Abies fraseri*) also have been severely affected. This species is endemic to mountaintops in the southern Appalachians. It is the codominant species with red spruce (*Picea rubens*) that together constitute the spruce-fir ecosystems found only at high elevations in this region. Adelgid infestations have eliminated mature trees from many locations. Although immature trees still persist in significant numbers, these will be attacked with increasing severity as they age. Therefore, the reproductive potential of the species may have been destroyed.

The North Carolina State Park Service tried intensive insecticide spraying at Mount Mitchell shortly after the detection of the adelgid in 1957. This technique proved effective in protecting individual trees but was ill-suited for use on a forest-wide scale. Until recently, the National Park Service in the Great Smoky Mountains National Park deployed an environmentally safe detergent spray to control the insect. This spray also proved too costly and labor intensive to be employed on a large scale (Langdon, personal communication).

Extensive research has been conducted to locate a biological control for the adelgid, but no effective biocontrol agents have been found. All apparently suitable insects were field-tested in eastern Canada over a 35-year period. No single predator or group of predators was found to be effective (Schooley *et al.* 1984). While some fun-

gal diseases are known to attack the adelgid, greenhouse and field studies in Quebec have not identified a successful control. The potential for control organisms from other locations is unknown (Schooley *et al.* 1984).

Scleroderris Canker

Scleroderris canker is caused by the fungus *Ascocalyx abietina* (= *Gremmeniella abietina*) and infests various coniferous species in North America, Europe and Asia (Skilling *et al.* 1986). The fungus usually causes tree mortality by producing cankers that girdle a large number of branches. Two strains of the fungus are known in North America. One, called the "North American" strain, has caused extensive damage in the Lake States since at least 1950 (*cf.* Skilling *et al.* 1986). This strain is thought to be native to the Rocky Mountains, where it causes minimal damage to coniferous species, *e.g.*, lodgepole pine (*Pinus contorta*) (Dorworth 1984). It attacks nursery stock and young plantations of red pine (*Pinus resinosa*), jack pine (*P. banksiana*), eastern white pine and the exotic Scots or Scotch pine (*P. sylvestris*). The fungus was spread by planting infested nursery stock, and affected approximately two-thirds of National Forest plantations in Michigan and Wisconsin by 1965. Approximately 40 percent of the seedlings planted were killed. Fungicide treatment of nursery stock and silvicultural procedures have now reduced the disease to manageable levels (Skilling *et al.* 1986.)

In 1975, *Gremmeniella abietina* was observed in New York, killing red and Scots pines of all ages (Setliff *et al.* 1977). Isolates were serologically identical to fungal isolates found in Europe (Dorworth *et al.* 1977); hence the strain was called the "European strain." Studies have shown that this strain has a wider range of hosts than the North American strain and could infest fir (*Abies*) and spruce (*Picea*) species as well as pine. The European strain presently occurs in northeastern North America and appears to be spreading (LaFlamme and LaChance 1987, Moody 1992). Intermediate strains, with the ability to attack trees of all ages, have been identified (Skilling *et al.* 1986.)

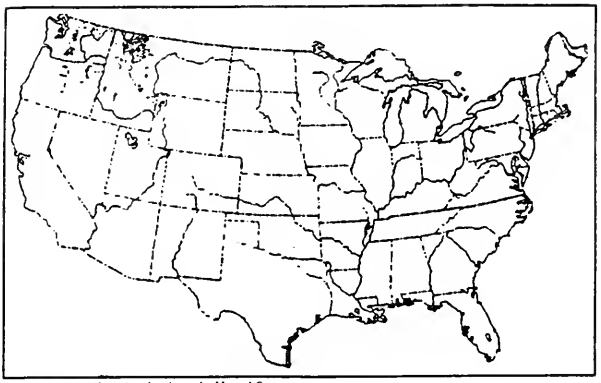
The European strain can be controlled in nurseries by spraying fungicides and young plantings by silvicultural practices. This strain, however, has the ability to attack mature trees, so silvicultural control is less effective than with North American strain infestations (Skilling *et al.* 1986).

Larch Casebearer

Eastern larch or tamarack (*Larix laricina*), and western larch (*Larix occidentalis*) are infested with larch casebearer (*Coleophora laricella*). The moth was introduced into Massachusetts in 1886, probably on imported nursery stock from Europe (Tunnock and Ryan 1983, Otvos and Quednau 1984). Initially infesting tamarack, the casebearer spread throughout the northeastern U.S. and southeastern Canada, reaching the Great Lakes region in the 1950s. By 1970, it was present in southeastern Manitoba (Otvos and Quednau 1984). In the West, the insect was discovered infesting western larch in Idaho in 1957 and was considered to be the species' most serious pest (Denton 1979). An outbreak occurred in British Columbia in 1966 (Otvos and Quednau 1984), and by 1982, all the U.S. range and most of the southern Canadian range of the western larch was infested (Tunnock and Ryan 1983). The moth larvae feed on the internal needle tissue causing defoliation. Five years of defoliation can kill a tree or reduce potential growth by as much as 97 percent (Tunnock *et al.* 1969). Younger trees growing in the open or along the edges of openings suffer the highest mortality (Tunnock and Ryan 1983).

Control strategies relying on a combination of natural factors and introduced parasites have been successful in eastern and central Canada and the northwestern U.S. (Otvos and Quednau 1984, Graham 1949, Ryan *et al.* 1987). The control organisms

used include two introduced European parasites, the braconid, *Agathis pumila* and eulophid, *Chrysocharis laricinellae*. In western North America, however, biological control using *Agathis pumila* was not satisfactory. Other parasites, including *Chrysocharis laricinellae*, were released from 1971 into the 1980s (Ryan *et al.* 1987). Long-term studies are under way to evaluate the effectiveness of the parasites (Ryan 1990).



Natural range of western larch in the United States

European Larch Canker

European larch canker disease infests species of the genus *Larix* and the Chinese monotype, *Pseudolarix amabilis*. This disease is caused by a fungus, *Lachnellula* (*Dasyscypha*) *willkommii*, and was first reported in North America in 1927 (Spaulding and Siggers 1927). The disease was effectively eradicated from Massachusetts by 1965 (Tegethoff 1965), but a new infestation was found in Canada in 1980 (Magasi and Pond 1982). Subsequently, infestations were observed in the coastal areas of eastern Maine (Miller-Weeks and Stark 1983). In those areas where the disease is present, the canker has infested and damaged 50 to 100 percent of the larch in plantations or young managed stands (USDA Forest Service 1991b). The severe impact of the canker on larch in parts of Europe and its potential impact on North American species has prompted Environment Canada, the USDA Forest Service, and the Maine Forest Service to issue public-information flyers urging extreme caution in transporting cuttings and seedlings (USDA Forest Service 1991b).

Pear Thrips

Pear thrips (*Taeniothrips inconsequens*) are native to Europe and were introduced to North America approximately in 1900 (*cf.* Carey *et al.* 1992). The insect was first described as a pest on fruit trees in California (Foster and Jones 1915), but recently has become a serious pest of sugar maple (*Acer saccharum*) (Parker *et al.* 1988). Pennsylvania foresters first observed defoliated trees in 1979, and pear thrips were identified as the causal agent. A subsequent inspection of survey records indicated that pear thrips were present in central Pennsylvania during the mid 1970s (Quimby 1990).

Pear thrips infestations are found in New England and the Great Lake States and are spreading to the midwestern region. Scientists cannot yet explain why pear thrips,

formerly known as pests of fruit trees, have switched host preference to sugar maples and other forest tree species. Damage is highly variable by year and geographic location. For example, Pennsylvania found 100,000 acres of heavy defoliation in 1982, virtually none in 1983 and 1984, and 110,000 acres of heavy defoliation in 1985 (Laudermilch 1988).

Control methods have not been developed yet. All pear thrips identified in the U.S. are females and are believed to reproduce by parthenogenesis (Laudermilch 1988).

Winter Moth

The winter moth (*Operophtera brumata*) feeds on various broadleaf trees, including maples, hawthorns, cherry, poplar, oaks, apple, and willow, in the Canadian Maritime provinces and U.S. Pacific Northwest forests. The moth was accidentally introduced into Nova Scotia, probably in the 1930s (Embree and Otvos 1984). By 1952, it had become a serious pest over much of Nova Scotia. Hardwood forests, particularly those containing northern red oak and wild apple, were severely defoliated. Two exotic parasites, *Cyzenis albicans* and *Agrypon flaveolatum*, were released from 1955 to 1959, and moth populations subsequently collapsed (Embree 1991). Moth populations in native forests of the Maritime provinces now appear to be controlled by a combination of life history factors and the two introduced parasites (Embree and Otvos 1984; Embree 1991). Sporadic outbreaks are now associated with early-leafing tree and shrub species, with little infestation of oak species (Embree 1984).

The winter moth was first reported in western North America in 1976 (Gillespie *et al.* 1978), but evidence indicates it had been established in Oregon for many years (Kimberling *et al.* 1986). It is unknown whether western infestations were due to a migration from eastern Canada or to a separate introduction from Europe (Kimberling *et al.* 1986). The distribution rate of the insect in Oregon has been slow, unlike the experience in Nova Scotia. The reason may be the lesser abundance of host plants on which leaf buds open sufficiently early for the moth to take best advantage (Kimberling *et al.* 1986). It is still too early to determine whether the parasites will be effective in British Columbia and Washington State (Kimberling *et al.* 1986).

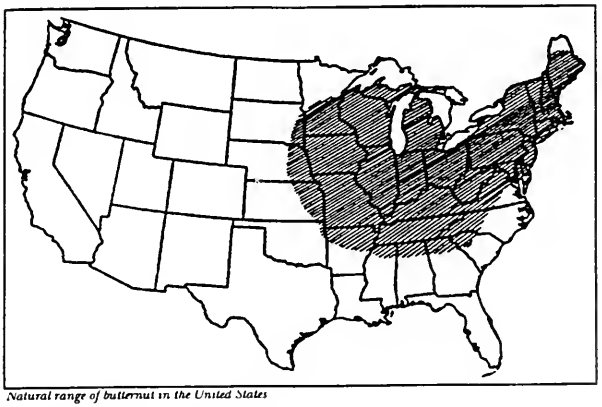
Winter moth has a broad host range and is adaptable to different temperature regimes. It is widespread in Europe and will probably continue to expand its range in North America.

Butternut Canker

Butternut or white walnut (*Juglans cinera*) is a highly valued hardwood species. The tree is closely related to black walnut (*Juglans nigra*), but can grow on a poorer, drier site. Butternut is harvested for veneer and lumber for furniture and carvings. The heartwood of butternut is lighter than black walnut and has a beautiful grain. Butternut is a hard mast species, producing nuts that are a component of many wildlife species' diets. The nut is palatable for human consumption, and 21 cultivars have been selected for orchard production (Millikan and Stefan 1989).

Butternut populations have been infested by the fungus *Sirococcus clavigignenti-juglandacearum*, that causes multiple branch and stem cankers. Cankers produced on the main stem will eventually girdle the tree and cause death. The disease was first discovered in 1967 in southwestern Wisconsin (Renlund 1971), but is believed to have originated from the eastern coast (Anderson and LaMadeleine 1978). Butternut canker has spread throughout much of the species' range. The 1991 Forest Insect and Disease Conditions in the United States survey (USDA Forest Service 1992) reports

new infestations in Vermont and emphasizes that "[butternut canker] disease has eliminated most of the butternut in the Southern region." Unlike chestnut, butternut will not sprout from the root crown when the top is killed by cankers. Seedlings and young sprouts are killed by the disease in addition to mature trees (Prey and Kuntz 1982). Therefore, when butternut canker destroys a population, that particular gene pool is lost forever as there is no possibility for reproduction.



Natural range of butternut in the United States

The devastation of butternut is occurring so rapidly that the species is currently a Federal Category 2 candidate for listing under the Endangered Species Act. In the northern National Forests (Forest Service, Region 9), it has been listed as a sensitive species. In southern states (Forest Service, Region 8), the National Forests in Mississippi consider butternut a sensitive species, and other southern National Forests have recommended the tree for sensitive species status.

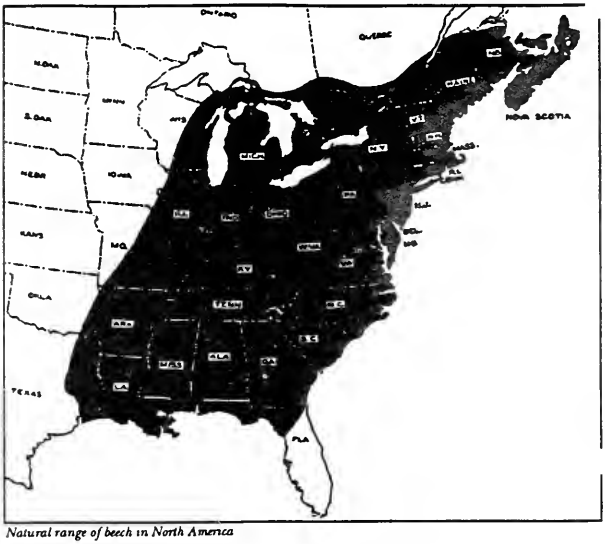
No known cures exist for the disease. Research to develop a disease-resistant tree began in 1989, years after the first infestation was documented. A few putative resistant trees have been found in various locations and are presently being evaluated (Anderson, personal communication).

Beech Bark Disease

American beech (*Fagus grandifolia*) is an important species in climax forests of eastern North America. The tree is utilized for lumber and pulp, and provides hard mast for wildlife species. Beech populations in the northeast have been infested with a disease complex that has caused extensive mortality or reduced productivity. This disease has now been found as far south as the Great Smoky Mountains National Park (Rhea, personal communication). The disease complex is composed of the exotic beech scale (*Cryptococcus fagisuga*) and fungi of the *Nectria* genus, *N. galligena* and/or *N. coccinea* var. *faginata*. The fungi enter the tree through holes in the bark caused by scale infestation. The resulting cankers can kill or disfigure the infested tree (Houston and Valentine 1988).

The beech scale was inadvertently imported into North America on European beech (*Fagus sylvatica*) nursery stock (Hawbolt 1944). By 1932, a survey in Maine revealed

that many forests were infested (Ehrlich 1984). In many northeastern stands, the disease has killed more than 50 percent of the beech population (USDA 1985). Along the "killing" front (*sensu* Shigo 1972), the disease is causing extensive mortality. Beech bark disease also kills sprouts from disease-killed trees (Burkman *et al.* 1993).



Natural range of beech in North America

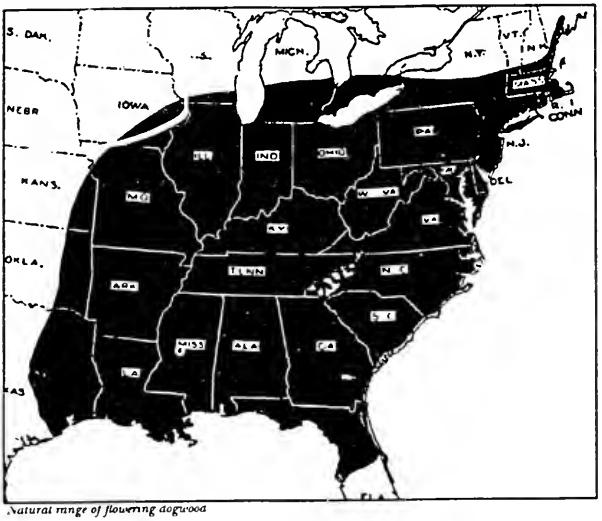
Chemical controls and detergent scrubbing have effectively controlled the scale on individual trees, but such measures are cost-prohibitive in forests. The scale has several natural enemies, the most prominent of which is the ladybird beetle (*Chilocorus stigma*). A fungus, *Nematogonum ferrugineum*, is a natural parasite of the *Nectria* fungus. The efficiency of this fungus, however, in curtailing the spread of the disease has not been adequately evaluated. Some beech trees are resistant to scale infestation (Shigo 1964, Cammermeyer 1993) and can be integrated into breeding programs.

Dogwood Anthracnose

The flowering and Pacific dogwoods (*Cornus florida* and *Cornus nuttallii*, respectively), are highly valued aesthetic components of eastern and western forests. Although dogwoods (*Cornus* species) are not important as a timber species, they are important as a mast supply for mammals and birds (*cf.* Mitchell *et al.* 1988). The fruit is high in protein and is a valuable food source for many migratory birds. The leaves and twigs of the dogwood provide browse for many herbivores, including deer. Fallen leaves from the dogwood contain a large amount of calcium and act as a major soil builder (Heiping 1971). In addition, the springtime floral display has not been ignored by the commercial nursery industry. Dogwood cultivars are extensively used in landscape plantings.

The opportunity for viewing the natural beauty of forest dogwoods may be limited in

some areas. An anthracnose disease is plaguing both the flowering dogwood in eastern forests and the Pacific dogwood in the Pacific Northwest. It has killed over 80 percent of the trees in some areas (US Forest Service 1991a). First discovered in Washington State in 1976 (Byther and Davidson 1979) and subsequently in New York in 1978 (*cf.* Pirone 1980), the disease has spread rapidly throughout eastern and western forests (Britton 1993). In southeastern North America, an estimated 5.7 million acres of forest were affected by 1990 (Chellemi *et al.*, in press). The fungus is most virulent in cool, continuously moist conditions, *e.g.*, high elevation dogwood populations proximal to water.



Natural range of flowering dogwood

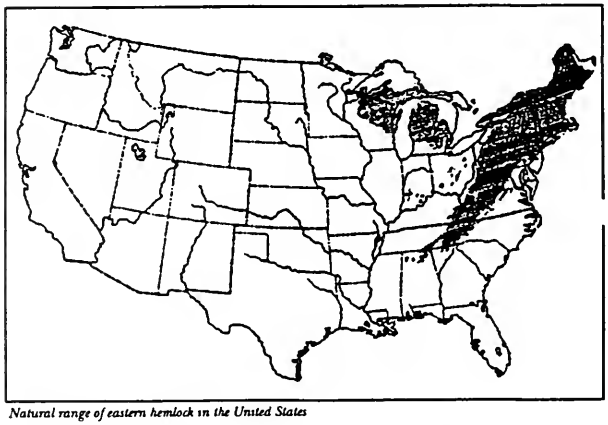
Dogwood anthracnose is a leaf and twig disease that is initially detected by leaf necrosis. The fungus *Discula destructiva* is now recognized as the causal agent (Redlin 1991). While the exact origin of the fungus in North America is uncertain, many scientists believe that the disease was introduced as it was first discovered near large port cities. Once infested, a tree will eventually become defoliated and may take several years to die. Occasionally trees are killed by annual cankers that can girdle the stem. Studies by Anderson *et al.* (1993) suggest that acid rain may predispose dogwoods to infestation and increase the severity of the disease. Contrary to forest-dwelling dogwoods, well-maintained trees in landscape plantings with full sun exposure often can survive (Swank and Smith, personal communication).

Public concern for the species' existence was increased when research failed to show resistance in population samples from 20 different states (Santamour *et al.* 1990). As a result, certain southern universities and the Forest Service have become extensively involved in assessing the spread, impact, and control of this pest. Surveys in Catoctin National Park have located putative resistant trees in areas where dogwood popula-

tions have been decimated (Langdon, personal communication; Windham, personal communication). Clones of these trees have shown varying degrees of resistance under greenhouse and field test conditions (Windham *et al.*, unpublished) and have been integrated into a breeding program.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (*Adelges tsugae*) attacks eastern hemlock (*Tsuga canadensis*), a commercially important species in eastern forests. The insect is believed to have been introduced into the U.S. from Asia (*cf.* McClure 1991) and was first reported in the Pacific Northwest more than 65 years ago (Annand 1924). The insect was first observed in eastern forests approximately 40 years ago in Virginia. The hemlock woolly adelgid has spread north into southern New England. The adelgid thrives in colder temperatures and is, therefore, likely to infest eventually the entire Northeast and eastern Canada (McClure 1989). A rapid increase in infested acreage was reported in New York in 1990, and northern New Jersey has 26,000 acres of infested hemlock. Apparently it is not spreading south as rapidly, as it has not yet been found in North Carolina (Langdon, personal communication).



Natural range of eastern hemlock in the United States

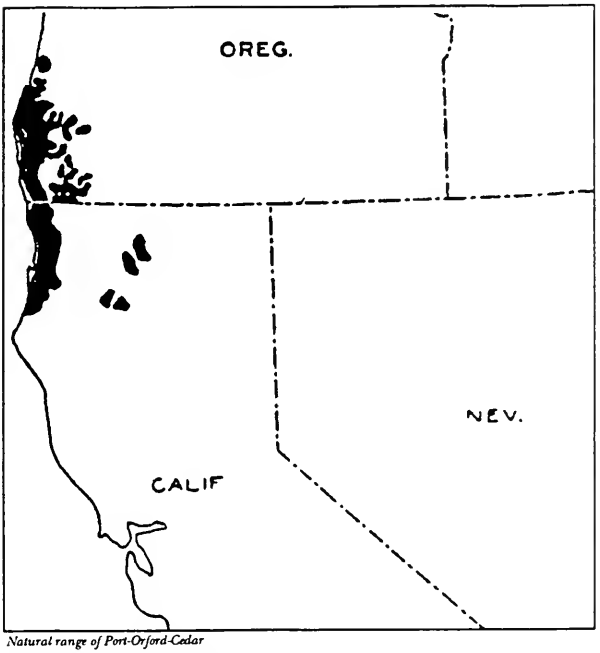
The adelgid probably injects the hemlock trees with a toxic saliva during feeding, as with the related balsam woolly adelgid (McClure 1991). Symptoms are foliage discoloration and dead branches. The tree usually dies within four years. All hemlocks are affected in a similar fashion, irrespective of age and size. Other introduced insects, the elongate and circular hemlock scales, have been found in conjunction with the adelgid (Burkman *et al.* 1993). These insects were introduced from Japan. Both scales can weaken and kill hemlocks, although not as rapidly as the adelgid (Stevens, personal communication).

No resistance to the adelgid has been recorded in eastern hemlock nor has effective biological control(s) been found. Pesticides, horticultural oil, and insecticidal soap have been effective in controlling infestation in nursery and urban plantings (McClure 1987). However, these methods are not applicable to or only partially effec-

tive in forest settings. The National Arboretum is presently engaged in obtaining seed source collections of different hemlock species to evaluate for resistance to this pest (Garvey, personal communication).

Port-Orford-Cedar Root Disease

Port-Orford-Cedar (*Chamaecyparis lawsoniana*) is endemic to a limited range along the Pacific Coast from Coos Bay, Oregon to northern California. Port-Orford-Cedar-dominated forests are florisucally diverse communities and are considered to be uniquely beautiful landscapes by recreational visitors. The species is valuable for its highly aromatic wood and is commercially widely used as a landscape plant. Native Port-Orford-Cedar populations have been decimated by a root disease caused by the exotic fungus *Phytophthora lateralis*. The disease was first reported in 1923 in a nursery near Seattle (Hunt in Zobel *et al.* 1985). The origin of *Phytophthora lateralis* remains unknown, although the partial resistance of Asian *Chamaecyparis* species has led some to speculate that it is Oriental in origin (Roth *et al.* 1987). The disease initially infests fine roots by directly penetrating into succulent tissues, and eventually colonizes the entire root system. Mortality occurs in seedlings within a few days, while a large tree may take several years to die. The fungus grows only in living tissue and is not found independently in the soil (Ostrofsky *et al.* 1977).



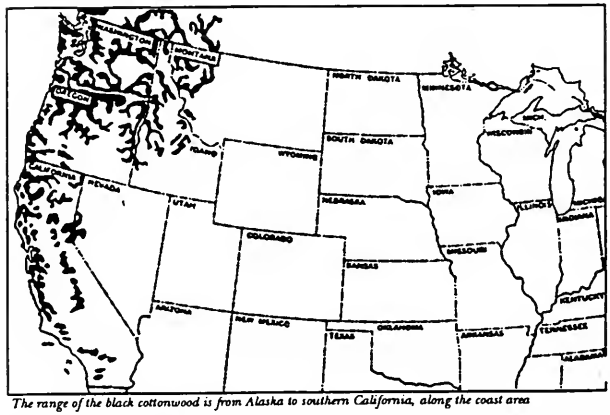
Natural range of Port-Orford-Cedar

By 1970, the disease had spread throughout the tree's range at lower elevations in Oregon (Kliejunas and Adams 1980). It is easily spread by movement of infested plant stock (landscape plants), including other species of *Chamaecyparis*. Zobel *et al.* (1985) conclude that the root disease "probably never would have emerged in epidemic form without the widespread planting of ornamental *Chamaecyparis* in northwestern Oregon and Washington." It is also spread through movement of spore-contaminated soil by machinery and animals. The spores germinate in water-saturated soil. Zobel *et al.* (1985) estimated that approximately 60 percent of the young regeneration has been killed by the disease. They concluded that without management techniques, or development of resistant stock, there is a limited future for commercial harvesting of Port-Orford-Cedar.

The restoration and/or preservation of Port-Orford-Cedar has been addressed by several different approaches. A project to hybridize Port-Orford-Cedar with more resistant *Chamaecyparis* species has been initiated (Roth *et al.* 1987). Control strategies, such as cleaning soil off of logging equipment, have also been implemented. To minimize the spread of infestation, recommendations have been made for strict management of human and animal (including wildlife) access to Port-Orford-Cedar stands in addition to removing trees proximal to water courses, road edges, and moist sites (Kliejunas and Adams 1980; Zobel *et al.* 1985).

Larch-Poplar Melampsora Rust

Black cottonwood (*Populus trichocarpa*) and quaking aspen (*Populus tremuloides*) are important components of Pacific Northwest forests. These species and various poplar hybrids are planted for fiber and ornamental uses (Newcombe and Chastagner 1993a) and are considered as a potential source of biomass for conversion to energy (Abelson 1991). In 1991, rusts were observed in several hybrid poplar plantations in western Washington and Oregon. The rusts were identified as *Melampsora medusae* f.sp. *deltoidae*, a species endemic to eastern North America, and *Melampsora larici-populina*, a Eurasian rust not previously reported in North America (*cf.* Newcombe and Chastagner 1993a). By December 1992, *M. larici-populina* infestations had been identified in an area about 30 miles wide along the lower Columbia River (Chastagner *et al.*



The range of the black cottonwood is from Alaska to southern California, along the coast area

1993) and from urban plantings and nurseries in many areas of California (Newcombe and Chastagner 1993b). The widespread nature of the infestation indicates that the rust has been present along the Pacific coast for years.

Melampsora larici-populina rust requires two hosts, a *Populus* species and a coniferous species, to complete its life cycle. In both hosts, poplar leaf rust can cause severe defoliation that reduces growth and may induce physiological disorders (Newcombe and Chastagner 1993a).

Other Exotic Pests

The preceding summaries of infestations represent examples of exotic pests that have caused notable destruction to a particular species or ecosystem. Forest Service staff have compiled lists of all exotic pests, insects, and diseases that have been introduced to North American trees, tree nurseries, and wood products. These lists now total over 300 species (Millers *et al.*, unpublished manuscript and personal communication). Some of the pests cause as much damage as the examples presented in this paper, *e.g.*, European spruce sawfly (*Gilpinia hercyniae*). Other pests damage trees in a less obvious manner, reducing vigor through feeding/parasitism or providing an environment for a secondary pest to invade the tree. A good example of a pest that probably causes widespread, but not lethal, damage is the Asiatic oak weevil (*Cyrtepistomus castaneus*). Larvae of this pest overwinter in the ground, feeding upon root hairs of the host plant. Adults feed upon the foliage of the host plant after emergence. Ferguson *et al.* (1992) suspected that damage from Asiatic oak weevils may negatively affect oak regeneration.

New pests are continuously being imported, despite APHIS regulations and quarantines. The common (or larger) pine shoot beetle (*Tomicus* (= *Blastophagus*) *piniperda*) was first discovered in July, 1992 infecting Scotch (Scots) pine near Cleveland, Ohio (Kucera 1992). Since the initial discovery, infestations have been found in New York, Pennsylvania, Illinois, Indiana, and Michigan. This pest has attacked a variety of Eurasian and North American pine species. APHIS has quarantined movement of logs, Christmas trees, and nursery stock of coniferous species from the infested states.

Eleven specimens of another exotic pest, the spruce beetle (*Ips typographus*), were captured in pheromone traps near a dunnage pile in the port area of Erie, Pennsylvania in spring 1993 (Hofacker 1993). While the Siberian risk assessment states that this insect normally utilizes dead wood (USDA Forest Service 1991b), Smith (personal communication) states that "[t]his insect is one of the most destructive pests of spruce in Europe; one outbreak destroyed an estimated 30 million cubic meters of wood. The beetle also killed millions of trees in Japan." APHIS and the Forest Service have placed numerous additional traps to document the spread of this pest and are searching for potential breeding areas to determine whether the beetle has become established in the area (Hofacker 1993).

Chapter 2: Potential Future Introductions

The increased controversy over cutting America's remaining old-growth forests has affected North American timber supplies in western forests and generated interest in importing logs from foreign countries. The dissolution of the Soviet Union and associated trade restrictions have opened the forests of Siberia to utilization by western nations. Other countries, such as New Zealand and Chile, also have raw materials available for the North American market. In relation to this paper, the most importar question raised by importation of logs are the possibilities of introducing new exotic pests into North America and reintroduction of existing exotic pests at new locations.

Siberian Importations

In response to pressure by scientists and politicians, APHIS requested the Forest Service to conduct an assessment of the risk of importing pests on logs from Siberia in 1991. The assessment team consisted of 43 forest scientists from federal and state agencies and universities. The team concluded that "the close similarity between [Siberia and similar latitudes of North America] promises to produce many taxa from Siberia that will find suitable hosts in various parts of the forests of Western North America.... Some species are likely to become serious pests" (USDA Forest Service 1991b). Siberian larch (*Larix siberica*) was assumed by the team as the primary species to be imported. The assessment team determined that 175 species of arthropods, nematodes, and fungi were associated with Siberian larch. They identified and reviewed 36 "representative" species from each of three groups that could be imported on logs with attached bark: pests residing on the outer bark, found inside the bark, or within the wood (USDA Forest Service 1991b).

An economic analysis predicting revenue losses was conducted, based on the assumption of infestation by the above 36 representative species. The analysis estimated the net present value of potential losses at between $24.9 million (best-case scenario) and $58 billion (worst-case scenario). These figures represented only the potential impacts to commercial timber species in the western U.S.; they did not consider ecosystem damage, impacts to nonconsumptive industries associated with forested land, or harm to agriculture.

Six of the "representative" pest species were examined in detail. The findings on these six pests are briefly summarized below.

Asian gypsy moth

The Asian strain of the gypsy moth (which belongs to the same species—*Lymantria dispar*—as the European insect) feeds upon more than 500 species of plants (Gibbon 1992), including many conifers and hardwood species. The Asian gypsy moth has a "moderate" potential to kill keystone hardwood tree species in healthy forests, and a "high" potential in stressed forests. The potential for extensive infestation of conifer forests is largely unknown but probably ranges from moderate to high (USDA Forest Service 1991b). Furthermore, unlike the European gypsy moth, the female Asian moth can fly up to 24 miles, carrying 600 to 700 eggs (USDA Forest Service 1991b, Gibbon 1992).

The Asian gypsy moth reached various Pacific port cities in North America in 1991 as egg masses on ships transporting grain. The United States and Canada immediately implemented an emergency control program. Aggressive spraying of the biopesticide, *Bacillus thuringiensis* ("Bt"), near the affected ports has apparently controlled the infestations. Meanwhile, Canadian authorities banned all ships that had visited potentially infested Siberian harbors from Canadian waters during the spring months when the eggs were likely to be hatching (Oliver, personal communication). The United States has relied on a voluntary agreement along the same guidelines. Both countries are monitoring gypsy moth population cycles near Siberian and North American ports. Asian gypsy moth infestations, however, would probably become extremely difficult to control if infestation repeatedly occurs at various Pacific ports.

An outbreak of gypsy moths in North Carolina in July 1993 was found to include Asian and European types, but predominantly hybrids between the two. This time, the insects had arrived on military equipment being shipped from Germany. Germany and other European countries are experiencing heavy infestations of gypsy moths this year, which apparently include hybrids. Shipments of all types of cargo from Europe could carry the insects to the United States (USDA Forest Service and APHIS 1993).

Nun moth

The nun moth (*Lymantria monacha*) is similar to the Asian gypsy moth in habits, development, and host utilization. If introduced, it is likely to attack all western conifers except pines. Tree mortality "is likely to be high." The potential area affected is 172 million acres in the United States and additional areas of Canada (USDA Forest Service 1991b).

Pine wood nematode

Several Asian species of pine wood nematode, including *Bursaphelenchus mucronatus* and *B. kolymensis*, are believed to pose the greatest threat to the Jeffrey and ponderosa pines (*Pinus ponderosa*) and other hard pines (USDA Forest Service 1991b). Ponderosa pine occupies nearly 5.7 million acres from British Columbia south into Mexico (Latin, personal communication; Skilling *et al.* 1986).

Larch canker

If introduced in the west (it is already present in eastern Canada and Maine), larch canker (*Lachnellula willkommii*) "could have a major impact on the 2 million acres of western U.S. forest with 50 percent or more larch cover." While the western larch's natural range is far from ports of entry, the canker might be spread on ornamental larches (USDA Forest Service 1991b).

Annosus root disease

Some Annosus root diseases are already causing damage on dry areas in western North America. If an exotic strain were to be introduced, it would have "a high potential to infest extensive areas of true fir and dry pine forests. Mortality in infested areas would probably be high." Other trees would suffer additional stress, becoming more vulnerable to other introductions or stresses (USDA Forest Service 1991b).

Spruce bark beetle

During epidemics, the spruce bark beetle (*Ips typographus*) spreads from dead or fallen spruce to standing spruce and sometimes pines and larches. The beetles carry various fungi, some of which are extremely pathogenic. The risk of introduction would be high in areas with spruce lumber or naturally dead spruce near coastal ports. Once introduced, the beetles could disperse by flight, eventually throughout the Pacific Northwest (including Alaska) and east along the boreal spruce forests to the Atlantic. If the beetle were accompanied by a more virulent fungus, such as *Ophiostoma polonica*, and native beetles also spread the fungus, "it could . . . be as disastrous to North American spruce as the Dutch elm disease was to elms." (USDA Forest Service 1991b).

In analyzing the threat posed by the potential introduction of Asian and Siberian tree "pest" organisms, the authors of the Siberian assessment stated,

> ...It is impossible to state the probability of extensive infestation.... However, since the risk of spread of these pests is high, large-scale infestations and tree mortality are likely to occur.... Loss of a significant proportion of living trees within stands would trigger complex changes in food supply and habitat.... Detrital food chains—fueled by dead organic matter—would be favored, while food chains that depend on living trees would collapse unless the system recovered very quickly.... (USDA Forest Service 1991b).

The Risk Assessment authors predict that mycorrhizal fungi, several species of voles, flying squirrels, and spotted owls could not make the transition to a detrital food chain. Deer and elk would be further limited by the increased scarcity of closed-canopy forests, which provide winter forage and shelter. Western yew, accipiter hawks, and salmonid fish would also decline (USDA Forest Service 1991b).

New Zealand Importations

In contrast to the size of the Siberian Risk Assessment Team, a risk assessment team for logs imported from New Zealand consisted of only five scientists, assisted by 11 experts from New Zealand. In a fashion similar to the Siberian assessment, this report gave detailed attention to only a few of the potential introductions: two diseases and five insect species. The total economic losses associated with introduction of the seven pests evaluated are estimated to fall between $52 and $364 million, exclusive of the costs of suppression, job loss, watershed damage, recreation, or ecological damage (USDA Forest Service 1992).

Latin (personal communication) has severely criticized the assessment as being too shallow and hurried. He notes that the report ignored several European pests now established in New Zealand. The assessment team originally failed to consult the major source on insects found on Monterey pine (*Pinus radiata*). Although this publication is included in the list of references, inspection of the report's text shows that the relevant information was not incorporated. Below are short summaries of the potential damage that two introduced pests from New Zealand could perpetrate on western forests.

Woodwasp-Amylostereum complex

The woodwasp *Sirex noctilio* and associated fungus *Amylostereum areolatum* can cause tree mortality. The wasp is native to Eurasia and North Africa, but it has become established in New Zealand, Australia, and southern South America. *Sirex noctilio* females fly (100-mile range) to locate physiologically stressed trees to deposit their eggs. The wasp primarily infests pine species, but has been recorded as infesting fir and spruce. During oviposition, the *Amylostereum* fungus with a toxic mucus are injected into the tree (USDA Forest Service 1992). In Australia and South America, this complex causes significant tree mortality. New Zealand controls the pest by biological control agents and improved stand management (USDA Forest Service 1992).

While the assessment ranks the risk of shipping infested *Pinus radiata* logs as low, there is a possibility of larval survival deep within the logs. If importation were to occur, the assessment considers that *S. noctilio* would probably become established and spread throughout the western United States. The authors estimate the economic costs resulting from establishment of the *S. noctilio-A. areolatum* complex at between $24 and $131 million in timber revenues alone (USDA Forest Service 1992).

Leptographium truncatum

The pathogen *Leptographium truncatum* is found on two North American endemic species, Monterey pine and eastern white pine, in New Zealand. The pathogen is considered by some to be the same as *L. lundbergii*, which attacks eastern white and loblolly (*Pinus taeda*) pines (USDA Forest Service 1992). The vector(s) for the fungi are not known with certainty, but bark beetles are suspected (USDA Forest Service 1992).

No effective method of controlling this fungus in logs is available. The assessment team considers that debarking would reduce the risk of transporting vectors from New Zealand, but North American beetles may be able to carry the fungus. Suitable tree hosts are found near the Pacific ports where imports are proposed (USDA Forest Service 1992) (as well as near Gulf Coast ports). Increased tree mortality in commercial forests, ornamental plantings, and Christmas tree plantations would be possible, with the greatest impact on native stands of Monterey pine (USDA Forest Service 1992).

Two pests already present in North America might be reintroduced from New Zealand. Diplodia shoot blight (*Diplodia pinea* = *Sphaeropsis sapinea*) and the previously discussed *Melampsora* poplar rust are pests in New Zealand forests. Importation of New Zealand logs without proper quarantine protocols presents the possibility of introducing more virulent strains or spreading infestation of these two pathogens to new areas.

New Zealand has had the reputation of applying stringent pest-exclusion programs for several decades. Since adoption of The Forests Act in 1949, the owner has had to pay the cost of inspections, searches, seizures, required treatment or destruction, etc. when importing raw wood. Experts considered that such precautions had helped limit establishment of new wood and bark boring insects to an average of one per year, despite increasing trade. They admitted, however, that "no method is available to estimate accurately how effective quarantine has been in preventing the establishment of forest pests" and that "[t]he effectiveness of New Zealand's quarantine procedures against fungal and other pathogens is difficult to evaluate because interceptions cannot be related to establishments" (Anonymous 1982).

Governmental surveys, carried out in the late 1970s and 1980s, focussed particular

concern on importing raw wood via "full container load" shipping containers. Nearly 50 percent of containers at the Port of Auckland during 6 months in 1978 had incorrect information on manifests as to wood content and 14 percent had no code. Forestry officials feared shippers had been deliberately miscoding the contents to avoid quarantine delay (Foley 1980). In consequence, a committee recommended more stringent controls on cargo shipments. The committee also recommended that the Ministry of Agriculture "automatically hold for inspection all foresters entering New Zealand, and should require formalised cleaning of boots, drycleaning of clothing worn in forests, etc." It further recommended inspecting and cleaning all camping gear used in foreign forests (Anonymous 1982).

New, stronger regulations were recently adopted. The Forest Produce Import and Export Regulations of 1989 require prior notice to the quarantine officer of estimated time of arrival of any vessel importing forest produce, and provision of a full manifest (including any pallets). Forest produce is defined to include timber and dunnage; dunnage does not include packing cases or pallets. If a quarantine inspector suspects infestation, he or she may require quarantine and treatment according to an appropriate prescription. The costs of inspection, excluding dunnage inspection, such as transport to a quarantine facility, treatment, etc., are paid by the importer.

Chilean Importations

A third risk assessment was conducted to address potential introductions of exotic pests on wood importations from Chile of Monterey pine and two indigenous hardwoods, coigue (*Nothofagus dombeyi*) and tepa (*Laurelia philippiana*). A six-member team assisted by both U.S. and Chilean experts conducted individual assessments of arthropods and diseases that have a probability of being introduced into this country. This report was released in September 1993 (USDA Forest Service 1993). The team examined the risk of introduction for ten insects and four types of diseases associated with Monterey pine. Risks associated with six major arthropods on coigue and two diseases common to both coigue and tepa were assessed by the team. Only "limited consideration" was given to other harmful pests, *e.g.*, nematodes, that "conceivably" could be associated with logs from Chile (USDA Forest Service 1993). No overall estimate of costs associated with these possible introductions was made.

After considering both risk of introduction and probable impacts in the spheres of economics, ecology, and public perception, the team ranked the risk from only one of the insect pests found on Monterey pine as "high." A bark beetle, *Hylurgus ligniperda*, could be a vector for the fungus *Leptographium* spp., which causes black stain root disease (USDA Forest Service 1993). A group of pathogens, classified variously as *Ophiostoma* or *Ceratocystis* spp., were ranked as "moderate to high" risks overall. Risk of introduction was considered "high." Economic and ecological damage were considered to be significant, however, only if Chilean strains of the fungi prove to cause vascular wilt (USDA Forest Service 1993). "Moderate" risks were assigned to ten species or groups associated with *Pinus radiata*, six found on coigue (USDA Forest Service 1993).

Comparison of the Assessments

A comparison of the Siberian, New Zealand, and Chilean risk assessments raises a number of troubling questions. The authors of the Chilean assessment note two disturbing tendencies not adequately addressed in the Siberian and New Zealand assessments. The first is the prevalence of bark-inhabiting insects on de-barked logs (USDA Forest Service 1993). We suggest that these reports confirm doubts about the effectiveness of de-barking as a phytosanitary measure. Second, the Chilean assessment

refers to the apparent frequency with which pests are transported in dunnage or crates (USDA Forest Service 1993). These data indicate the need to incorporate such material into phytosanitary controls on wood imports. Mitigation procedures for dunnage associated with imports from Siberia and New Zealand were not discussed in their respective risk assessments.

Another inconsistency among the reports is the level of risk assigned to a particular pest or pest complex. The risk can vary considerably without an apparent explanation. As an example, the New Zealand assessment assigned a high risk to the woodwasp and its associated fungus (USDA Forest Service 1992). In contrast, the *Sirex/Amylostereum* complex is only briefly mentioned in the Siberian assessment (under a different generic name for the wasp, *Paururus*), and no risk is assigned (USDA Forest Service 1991b). In addition, several reviewers of the draft assessments expressed concern over the level of risk assigned to possible reintroductions of pests already present in North America. Their comments focus on the possibility that an introduction of a different genetic strain or variety would increase damage to current host species and/or expand the host range.

The lack of knowledge of foreign tree species' biology and interactions with pests in their native environment was emphasized in the Chilean assessment. In several passages, the authors complained that the paucity of information on most indigenous pests of the hardwood species hampered the assessment of their impact in North America. Without this information, assessments could underestimate potential pests and associated damage to North American forests.

Chapter 3: The Need for a Comprehensive Pest Prevention and Management Program

The current and future demands on forest resources for multiple uses make it essential that a comprehensive national program on integrated pest management be developed and funded. The program should be designed to address exotic pests presently within the country and to prevent or minimize the introduction of new pests from abroad. The framework for a national integrated pest management program already exists under the authorizing statutes for both APHIS and the Forest Service: the Federal Plant Pest Act (7 U.S.C. §§ 150aa -150jj); the Organic Act (7 U.S.C. §§ 147a - 147e); the Forest and Rangeland Renewable Resources Research Act (16 U.S.C. § 1642); and the Cooperative Forestry Assistance Act (16 U.S.C. §§ 2101, 2102, 2104). (For brief summaries of these statutes' provisions, see Appendix A.)

Prevention of Exotic Pest Introduction

For many years, it has been recognized that the most efficient method to eliminate exotic pest infestation is to prevent the organism from entering the country (*cf.* Boyce 1961). The responsible agency is APHIS. APHIS has traditionally concentrated, however, on the prevention of new agronomic and horticultural crop-related pests. As discussed in the Introduction, there are no general plant health (phytosanitary) regulations that specifically govern timber imports. APHIS has relied upon a visual inspection of logs at U.S. ports to detect insects and pathogens. This inspection policy is now antiquated with the advent of large-scale timber importations from other countries. The Siberian Risk Assessment analysis clearly illustrates that visual inspection is insufficient for adequate protection against introduction of foreign pests.

Regulatory controls intended to prevent the introduction or spread of exotic pest species are not completely effective. An additional measure of protection could be a quarantine. Unfortunately, APHIS is not adequately financed or staffed to manage the large quarantine program that would be needed for raw wood products. Another approach is to organize a defense strategy prior to introduction (Boyce 1961). We believe that a much more aggressive prevention program is needed to increase protection for North American forests. APHIS should not wait until the foreign organism has been introduced to begin an emergency eradication or control campaign. In-

stead, virulent pests in foreign countries that have a potential to attack North American trees should be studied to obtain information to prevent or delay introduction to this continent. Potential pests can be evaluated by planting North American species in infested areas of foreign countries to measure susceptibility. Alternately, pests can be imported into a USDA-approved quarantine facility and evaluated under controlled conditions.

While APHIS has not yet adopted a comprehensive policy, as above, it is willing to increase the effectiveness of its pest exclusion efforts through new regulations. In September 1992, APHIS announced an intent to propose general regulations that would govern "unprocessed wood" products that could transport nonindigenous or not previously introduced pests (see 57 *Federal Register*, No. 184, pp. 43628-43631). The agency sought input on mitigation measures for different "unmanufactured wood products" exported from different countries. APHIS also invited suggestions as to whether the agency should have considerable flexibility in the future to revise import requirements, or whether it should be required to seek public comment before adopting any future revisions.

Twenty-eight wood importers and trade associations responded to the APHIS notice. Many of the importers and trade associations recognized the risk of pest introduction, but all argued that any regulation must be a reasonable response to "real" rather than "imaginary" risks, economically feasible, and in compliance with free-trade principles. The association of Northwest Independent Forest Manufacturers argued that such high-value wood products as Siberian larch should be imported under less stringent regulations as part of balancing risk against benefit.

Many companies and associations supported adoption of a "universal" rule, but then argued that their particular import, *e.g.*, wood chips from Canada or Mexico, should be subject to less restrictive regulation or exempted completely. Several asserted that tropical woods posed no threat as pests would be killed by winter freezes. However, some firms plan to import chips from pine and other species from plantations in the tropics to Gulf Coast or California ports which are near native pine forests and plantations where freezing temperatures are relatively infrequent.

The assertion that importation of logs from neighboring countries belonging to species native to the United States should cause less concern was expanded by the American Forest Council to include Monterey pine plantations in distant countries. Arguing that Monterey pine plantations "may not be subject to the same insects and pests as exotic [tree] species[,]" the Council concluded that Monterey pine imports should be subject to less stringent phytosanitary regulation than imports of species not native to North America. The American Forest Council has failed to recognize that importations of North American tree species grown in another country should be *more* stringently regulated than nonnative species. A greater probability of successful infestation exists when the imported host species is native to the area of introduction.

Recommendations Re: Raw Wood Imports

The authors of this paper firmly believe that quarantine procedures should be developed for all categories of raw wood imports, including logs and wood chips. However, we are not sufficiently expert to determine the most effective quarantine measures to ensure exclusion of forest pests. The reports by the three risk assessment teams and the Siberian mitigation advisory team are good examples of the interdisciplinary cooperative effort needed to analyze a specific importation situation with a potential to cause pest problems, and then to develop reasonable protocols to insure against

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the introduction of exotic pests. We suggest that APHIS, in cooperation with other governmental agencies and the private sector, define the different categories of raw wood products and correspondingly develop new inspection procedures and quarantine protocols for each individual category.

New APHIS regulations regarding raw wood importation should be uniformly applied to imported materials regardless of the country of origin, with the possible exception of Canada. It is conceivable that infested raw wood materials could be shipped to a country and infest that country's forests, and that the newly infested forests could be in turn harvested and the infested materials shipped to the United States. Indeed, many of the pests now of concern on New Zealand logs are exotic to that island nation. Alternately, any country exempted from phytosanitary restrictions has the potential to become a "laundry" for raw wood materials entering the United States indirectly or under false pretenses as in some New Zealand importations. As indicated, the exemption of Canada from new APHIS regulations could be a possibility. Canadian importation regulations are stringent and our forests are contiguous, complicating efforts to prevent cross-border infection. (However, regional quarantines applying to infested species in either or both countries are appropriate.)

After considering expert advice, APHIS should draft a set of procedures and, in compliance with standard regulatory procedures, publish it for public review. All interested parties should be given an opportunity to submit comments on specific provisions as well as general issues and any conflicts among viewpoints should be resolved in the public forum.

Stringent regulation of raw wood imports may not be sufficient. At least seven pests of native tree species discussed in this paper were introduced on nursery stock, and two other pests were dispersed within North America on such material. APHIS has existing authority in this area and may need to review regulations regarding importatic of all woody plants.

Management of Current Exotic Pests

Under the broad wording of the Federal Plant Pest Act and the Organic Act, APHIS has the primary responsibility to ensure that imported plant and animal species do not contain pests "which can directly or indirectly injure or cause disease or damage in any plants or parts thereof" and to detect, eradicate, control, or retard the spread of plant pests. Within the United States, however, APHIS has largely ceded this authority for forest pests to the Forest Service. APHIS lacks adequate funds to participate in eradication or control measures of all exotic pests. The agency currently spends about $2.25 million on tree pests, 70 percent of it to prevent establishment of the Asian gypsy moth (McGovern, personal communication).

The Forest Service may conduct research and experiments to obtain, analyze, develop, demonstrate, and disseminate scientific information about protecting and managing forests for a multitude of purposes, under the auspices of the Forest and Rangeland Renewable Resources Research Act. Forest protection specifically includes addressing insect and disease problems. A second statute, the Cooperative Forestry Assistance Act, authorizes the Forest Service to protect from insects and diseases trees and wood products in use on National Forests or, in cooperation with others, on other lands in the United States. Such assistance may include surveys and determination and organization of control methods. The Forest Service is further authorized to provide assistance to state foresters to develop and distribute genetically improved tree seeds and to improve management techniques aimed at increasing production of a variety of forest products, including wildlife habitat and water.

Funding for management of exotic pest infestations is unfortunately crisis-oriented. Seventeen years ago, a National Academy of Sciences (1975) report found that, "In the area of pest control research, priorities have often been set under political pressures for immediate answers, with too much regard for short-term problems and too little consideration for broader management objectives. Part of this problem arises from portions of the Forest Pest Control Act of 1947 that...tend[s] to promote an 'action' attitude that may inhibit solutions other than short-term, direct chemical control" (National Academy of Sciences 1975). Butternut canker and dogwood anthracnose are good examples of diseases that were allowed to decimate tree populations with little attention, until recently, to controlling these pests or breeding resistant tree varieties.

Total expenditures by agencies of the USDA to combat exotic pests of trees in fiscal year 1993 approached $19 million. The vast preponderance was spent by the Forest Service: $11.8 million by the Forest Pest Management program (Lorimer, personal communication), $1.23 million by Forest Insect and Disease Research (Smith, personal communication), and $1.45 million by the Timber Program tree improvement program (Miller, personal communication).

Two other agencies of USDA also contributed to the effort. Expenditures by APHIS vary considerably from year to year because it responds to introductions when they are detected. Thus, in fiscal year 1992, APHIS spent $20 million on efforts to eradicate the Asian gypsy moth. In fiscal year 1993, APHIS allocated only $2.25 million for preventing the dissemination of introduced exotic tree pests into the country. This figure does not include APHIS' port inspection program effort devoted to wood imports (a small proportion compared to inspections of fruits, vegetables, live plants, etc.) or administrative costs (including APHIS' costs associated with preparing either the country-specific risk assessments or the more general regulations to govern imports of "unprocessed wood" products) (McGovern, personal communication). Finally, the Agricultural Research Service is spending $350,000 on research on dogwood anthracnose and $1.9 million on gypsy moth research (Faust).

Over two-thirds of all USDA tree pest control funds ($13 million from the Forest Service's Forest Pest Management program and Agriculture Research Service) are devoted to efforts to suppress or eradicate the European gypsy moth. An additional $1.8 million is being spent, largely by APHIS, to monitor Asian gypsy moth populations in Siberia and ships entering our ports to prevent a re-introduction of this insect. In sum, over three-quarters of all USDA tree pest control funds were gypsy moth-related.

Pest control in the white pine group received a total of over $2 million dollars in Forest Service funds. The bulk of this amount funds a western white pine blister rust breeding program. Several introduced pests or pathogens received funding at levels between $600,000 and $700,000. These included the European pine shoot beetle, which was discovered in the Lake States in 1992; and dogwood anthracnose. Dutch elm disease control efforts received $544,000. The only other pest control program receiving more than $100,000 was the hemlock woolly adelgid. Other trees threatened by exotic pests, fungi, or disease pathogens — Port-Orford-Cedar, butternut, beech, and chestnut — were funded at levels of from $52,000 down to $14,000.

Recommendations Re: A Comprehensive Program

We see no need to create new institutions to implement a truly comprehensive pest prevention and management program for America's forests. The various tasks should

be conducted by existing institutions under existing legal authorities. However, these agencies must act out of a new appreciation for forest *ecosystems*, not just concern for timber production. Cooperation and coordination among the various agencies must improve. Finally, funding for APHIS, the Forest Service, and cooperating state agencies will have to be increased substantially.

We envision that APHIS will retain its emphasis on exclusion; expand quarantines to prevent spread of incipient infestations; where possible, eradicate incipient infestations; continue funding some research; and conduct research on pests and control measures in countries from which raw wood products and nursery stock would be imported.

The Forest Service would continue to lead research and application of control measures in the United States. The work should be in active collaboration with state forestry divisions and universities. Other interest groups which are affected by the decline of America's forests or contribute to the threat by importing items which could carry pest organisms should contribute knowledge, funds, public education efforts, and other resources to improving our understanding of and efforts to contain exotic pests of trees. These interest groups would include the forest industry, nursery industry, recreation industry, ecologists, and wildlife management and conservation organizations. Wider involvement of the conservation movement would augment efforts by citizen organizations such as the American Chestnut Foundation.

In testing and adopting control methods, all parties must recognize the environmental impacts of those methods. It is important to emphasize that environmental and financial costs are associated with *both* courses of action—applying pest control measures and allowing the exotic pest to damage tree species and their associated ecosystems. A difficult, careful balancing of these countervailing environmental costs is inheren in adopting our recommendations.

As we noted earlier, funds must be considerably increased over current levels. As the continuing damage to native forests by exotic pests and new dangers posed by potential importation of raw wood products prompted this paper, it is tempting to conclude that expanded pest management programs should be funded by timber and paper industries' revenue. Yet if forests are to be truly managed as ecosystems, i.e., for multiple use, the burden of costs must be shared by all users, including timber producers and consumers, conservationists, recreationists, and preservationists. Because the identification, testing, and application of mitigation and control measures for introduced pests require years of dedicated effort, it is essential that funds also be stable, to prevent interruptions of long-term projects.

We support the Forest Service's recent initiative to create an emergency fund of up to $3 million to enable rapid start-up of research on newly introduced pests which threaten native forests. In just the past two years, the Asian gypsy moth, European pine beetle, *Melampsora* fungus, and European spruce beetle have been discovered at our ports or in our forests. A prompt response is necessary to minimize damage from the pest, but, since the occurrence and size of such introductions cannot be anticipated years in advance, the amount of funding needed cannot be determined during the normal, lengthy, budget-development process.

Another Forest Service initiative, the National Center of Forest Health Management, is an encouraging step toward comprehensive pest management. The Center's goals are: 1) "with partners, promote and facilitate development and use of technologies to

sustain or enhance forest health," and 2) "advance understanding of forest health and effects of forest health technologies on forest ecosystem and management goals." Three work areas will be focused upon: 1) biorational methods, 2) biological control, and 3) nontarget effects.

A comprehensive pest prevention and management program for America's forests will be expensive, but it is an investment well worth making. At stake are financial outlays by the Forest Service and APHIS, lost fiber production, and the ecological health of some of the most treasured elements of our natural heritage.

Literature Cited

Abelson, P.H. 1991. Improved yields of biomass. Science 252: 1469.

Andreadis, T.G. and R.M. Weseloh. 1990. Discovery of *Entomophaga maimaga* in North American gypsy moth *Lymantria dispar*. Proc. Natl. Acad. Sci. U.S.A. 87: 2461-2465.

Allen, D. and T.W. Bowersox. 1989. Regeneration in oak stands following gypsy moth defoliations. *In* Proc. 7th Central Hardwood Conf., G. Rink and C.A. Budelsky, eds., Gen. Tech. Rep. NC-132. United States Department of Agriculture Forest Service, North Central Experiment Station. pp. 67-73.

Anderson, R.L., P. Berrang, J. Knighten, K.A. Lawton, and K.O. Britton. 1993. Pretreating dogwood seedlings with simulated acidic precipitation increases dogwood anthracnose symptoms in greenhouse-laboratory trials. Can. J. For Res. 23: 55-58.

Anderson, R.L. and L.A. LaMadeleine. 1978. The distribution of butternut decline in the eastern United States. United States Department of Agriculture, Forest Service, NE Area, State and Private Forestry Report S-3-78. 4 pages.

Anderson, R.L. Plant Pathologist, United States Department of Agriculture, Forest Service, Asheville, North Carolina. Personal communication to F.T. Campbell.

Annand, P.N. 1924. A new species of *Adelges* (Hemiptera, Phylloxeridae). Pan-Pac. Entomol. 1: 79-82.

Annand, P.N. 1928. A Contribution toward a monograph of the Adelginae (Phylloxeridae) of North America. Stanford Univ. Press, Palo Alto, Calif. 146 pages.

Anonymous. February 1982. "A Review of Import Quarantine as it Affects Forestry in New Zealand."

Baker, W.L. 1941. Effect of gypsy moth defoliation on certain forest trees. J. For. 39: 1017-1022.

Balch, R.E., J. Clark and J.M. Bonga. 1964. Hormonal action in production of tumors and compression wood by an aphid. Nature 202: 721-722.

Bingham, R.T. 1983. Blister rust resistant western white pine for the Inland Empire: the story of the first 25 years of the research and development program. USDA Forest Service General Technical Report INT-146. 45 pages.

Boyce, J.S. 1961. Forest Pathology, Third Edition, McGraw-Hill Book Company, Inc. New York.

Britton, K.O. 1993. Anthracnose infection of dogwood seedlings exposed to natural inoculum in western North Carolina. Plant Dis. 77: 34-37.

Burgess, A.F. and S.S. Crossman 1929. Imported insect enemies of the gypsy moth and the brown-tail moth. United States Department of Agriculture Tech. Bull. 86, 148 pages.

Burkman, W.Q. Chavez, R. Cooke, S. Cox, S. DeLost, T. Luther, M. Mielke, M. Miller-Weeks, F. Peterson, M. Roberts, P. Seve, and D. Twardus. 1993. Northeastern Area Forest Health Report. NA-TP-03-93. United States Department of Agriculture, Forest Service. Northeastern Area State and Private Forestry, Radnor, Pa.

Burnham, C.R., P.A. Rutter and D.W. French. 1986. Breeding blight-resistant chestnuts. Plant Breed. Rev. 4: 347-397.

Byther, R.S. and R.M. Davidson, Jr. 1979. Dogwood anthracnose. Ornamental Northwest News. 3. 20-21.

Cammermeyer, J. 1993. Life's a beech—& then you die. Am. Forests July/August 1993, pp. 20-21, 46.

Campbell, R.W. 1975. The gypsy moth and its natural enemies. United States Department of Agriculture, For. Serv. Bull. No. 381, 27 pages.

Carey, E., R.G. Van Driesche, and J.S. Elkinton. 1992. Influence of sugar maple health on fecundity of pear thrips in Massachusetts. Can Ent. 124: 1129-1138.

Chastagner, G., G. Newcombe, and J. Staley. 1993. Development of leaf rust in hybrid poplar plantations during 1992. Washington State University. Poplar Leaf Rust Workshop. February 24, 1993.

Chellemi, D.O., K.O. Britton, W.T. Swank. "Influence of Site Factors on Dogwood Anthracnose in the Nantahala Mountain Range of Western North Carolina." Plant Disease (in press).

Choi, G.H. and D.L. Nuss. 1992. Hypovirulence of chestnut blight fungus conferred by an infectious viral cDNA. Science 257: 800-803.

Corbett, E.S. and J.A. Lynch. 1987. The gypsy moth—does it affect soil and water resources? *In* S. Fosbroke and R.R. Hicks Jr. (eds.). Coping with the gypsy moth in the new frontier. W. Va. Univ. Books, Morgantown, WV, pp. 39-46.

Crandall, R.S., G.F. Gravatt, and M.M. Ryan. 1945. Root disease of *Castanea* species and some coniferous and broadleaf nursery stocks caused by *Phytophthora cinnamomi*. Phytopath. 35: 162-180.

Cunningham, J.C., W.J. Kaupp, R.A. Fleming, K.W. Brown, and T. Burns. 1993. Development of nuclear polyhedrosis virus for control of gypsy moth (Lepidoptera: Lymantriidae) in Ontario. II. Reduction in dosage and emitted volume (1989 and 1990). Can. Ent. 125: 489-498.

Denton, R.E. 1979. Larch casebearer in western larch forest. United States Department of Agriculture, For. Serv. Gen. Tech. Rep. INT-55. 62 pages.

Literature Cited

Dermen, H. and C. May. 1966. Colchiploidy of *Ulmus pumila* and its possible use in hybridization with *U. americana*. Forest Sci. 12: 140-146.

Diller, J.D. and R.E. Clapper. 1965. A progress report on attempts to bring back the chestnut tree in the eastern United States, 1954-1964. J. Forestry 63: 186-189.

Diller, J.D. and R.E. Clapper. 1969. Asiatic and hybrid chestnut trees in the eastern United States. J. Forestry 67: 528-531.

Dorworth, C.E. 1984. History of Scleroderris canker in Canada. *In* Scleroderris canker of conifers. P.D. Manion (ed.), Martunus Nijhoff/Dr W. Junk Publishers, pp. 5-7.

Dorworth, C.E., J. Krywienczyk, and D.D. Skilling. 1977. New York isolates of *Gremmeniella abietina* (*Scleroderris lagerbergii*) identical in immunogenic reaction to European isolates. Plant Dis. Rep. 61: 887-890.

Drost, Y.C. and R.T. Carde. 1992. Host switching in *Brachymeria intermedia* (Hymenoptera: Chalcididae), a pupal endoparasitoid of *Lymantria dispar* (Lepidoptera: Lymantriidae). Environ. Entomol. 21: 760-766.

Ehrlich, J. 1934. The beech bark disease. A *Nectria* disease of *Fagus*, following *Cryptococcus fagi* (Baer.). Can. J. Res. 10. 593-692.

Embree, D.G. 1991. "The winter moth *Operophtera brumata* in eastern Canada, 1962-1988." *In* Forest Ecology and Management. Elsevier Science Publishers B.V. Amsterdam, 39 (1991).

Embree, D.G. and Otvos, I.S. 1984 "*Operophtera brumata* (L.), Winter Moth (Lepidoptera: Geometridae)." In J.S. Kelleher and M.A. Hulme (eds.). Biological Control Programmes against Insects and Weeds in Canada 1969-1980. Commonwealth Agricultural Bureaux, England.

Faust, R.M. 1992. "USDA-ARS National Research Action Plan for Development of Technologies for Management and Suppression of the Gypsy Moth *Lymantria dispar*." ARII United States Department of Agriculture, Agricultural Research Service, 1992.

Ferguson, C.S., M.J. Linit, and G. Krause. 1992. Dispersion and density of Asiatic oak weevil (Coleoptera: Curculionidae) relative to oak density. Environ. Entomol. 21: 247-252.

Foley, T.A. New Zealand Forest Service. 1980. "Interception of Foreign Pests and Diseases." 11th Commonwealth Forestry Conference, September 1980.

Foster, S.W. and P.R. Jones. 1915. The life history and habits of pear thrips in California. USDA Bulletin No. 173. 52 pages.

Garrett, P.W. 1986. Role of tree improvement in providing pest-resistant eastern white pine (*Pinus strobus* L.). *In* Eastern White Pine: Today and Tomorrow Symp. Proc., U.S. Dep. Ag. For. Serv. Gen Tech. Rep. WO-51, pp. 75-88.

Garvey, E.J. United States Department of Agriculture, Agricultural Research Service, National Arboretum. Personal communication to S.E. Schlarbaum.

Gibbon, A. 1992. "Asian Gypsy Moth Jumps Ship to United States." Science. Vol. 255. January 31, 1992.

Gillespie, D.R., T. Finlayson, N.V. Tonks, and D.A. Ross. 1978 Occurrence of the winter moth *Operophtera brumata* (Lepidoptera: Geometridae) on southern Vancouver Island, British Columbia. Can. Entomol. 110 223-224.

Goebl, M. 1987. Gypsy moth infestation on the Allegheny National Forest has direct impacts on recreationists. *In* Coping with the gypsy moth in the new frontier, S. Fosbroke and R.R. Hicks, Jr., eds., W. Va. Univ. Books, Morgantown, WV, pp. 59-64.

Gottschalk, K.W. 1993. Silvicultural guidelines for forest stands threatened by the gypsy moth. United States Department of Agriculture, Forest Service General Technical Report NE-171. 50 pages.

Graham, A.R. 1949. Developmental in the control of the larch case bearer, *Coleophora laricella* (Hbn.). *In* 79th Ann. Rep. of the Entomological Soc. of Ontario (1948). pp. 45-50.

Hajek, A.E. and D.W. Roberts. 1992. Field diagnosis of gypsy moth (Lepidoptera: Lymantriidae). Larval mortality caused by *Entomophaga maimaiga* and the gypsy moth nuclear polyhedrosis virus. Environ. Entomol. 21: 706-713.

Hajek, A.E., R.A. Humber, J.S. Elkinton, B. May, S.R.A. Walsh, and J.C. Silver. 1990. Allozyme and restriction fragment length polymorphism analyses confirm *Entomophaga maimaiga* responsible for 1989 epizootics in North American gypsy moth populations. Proc. Natl. Acad. Sci. U.S.A. 87: 6979-6982.

Hawbolt, L.S. 1944. History of spread of beech scale, *Cryptococcus fagi* (Baerensprung), an insect introduced to the Maritime provinces. Acadian Nat. 1: 137-146.

Hay, R.L. 1978. Fraser fir in the Great Smoky Mountains National Park: Its demise by the balsam woolly aphid (*Adelges piceae* Artz.). Department of Forestry, Wildlife, and Fisheries, The University of Tennessee, Knoxville. 125 pages.

Hepting, G. 1971. Disease of forest and shade trees of the United States. United States Department of Agriculture, Forest Service Agricultural Handbook No. 386. 658 pages.

Herrick, O.W. and D.A. Gansner. 1987. Gypsy moth on a new frontier: forest tree defoliation and mortality. Northern J. Appl.

Literature Cited

For. 4: 128-135.

Hirt, R.R. 1948. Evidence of resistance to blister rust by eastern white pine growing in the Northeast. J. For. 46: 911-913.

Hofacker, T.H. 1993. United States Department of Agriculture, Forest Service Staff Entomologist. Memorandum of meeting on May 28, 1993 (undated).

Hoff, R. and S. Hagle. 1989. Diseases of whitebark pine with special emphasis on white pine blister rust. *In* Proceedings—Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource. Bozeman, MT. March 29-31, 1989. Schmidt, W.C., and K.J. McDonald, Compilers. pp. 179-190.

Hollenhorst, S.J., S.M. Brock, W.A. Fremund and M.J. Twery. 1993. Predicting the effects of gypsy moth on near-view aesthetic preferences and recreation appeal. For. Science 39: 28-40.

Houston, D.R. and H.T. Valentine 1988. Beech bark disease: the temporal patterns of cankering in aftermath forests of Maine. Can. J. For. Res. 18: 38-42.

Hunt, J. 1957. Early History of Port-Orford Cedar Root Rot. Unpublished report to U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 2 pages (*fide* Zobel *et al.* 1985)

Johnson, K.D. 1980. Fraser fir and woolly balsam adelgid: a summary of information. Southern Appalachian Research/ Resource Management Cooperative, Western Carolina University, Cullowhee, North Carolina. 62 pages.

Karnosky, D.F. 1979. Dutch Elm Disease: A Review of the History, Environmental Implications, Control, and Research Needs. Environmental Conservation. Vol. 6, no. 4, 1979.

Ketcham, D.E., C.A. Wallner, and S.S. Evans, Jr. 1968. Western white pine management programs realigned on northern Rocky Mountain National Forests. J. Forestry 6: 329-332.

Kendall, K.C. and S.F. Arno. 1989. Whitebark pine—an important but endangered wildlife species. *In* Proceedings—Symposium on Whitebark Pine Ecosystem: Ecology and Management of a High-Mountain Resource. Bozeman, Mt. March 29-31, 1989. Schmidt, W.C. and K.J. McDonald, Compilers. pp. 264-273.

Kimberling, D.N., J.C. Miller, and R.L. Penrose. 1986. "Distribution and Parasitism of Winter Moth, *Operophtera brumata* (Lepidoptera Geometridae), in Western Oregon." Environmental Entomology. Vol. 15, No. 5. October, 1986.

Kliejunas, J. and D. Adams. 1980. "An Evaluation of Phytophthora Root Rot of Port-Orford-cedar in California," United States Department of Agriculture, Forest Service, Region Five, Report No. 80-1, November 1980.

Kounsky, J. 1916. The European fir trunk louse, *Chermes* (*Dreyfusia*) *piceae* (Ratz.). Ent. Proc. Soc. Washington 18: 14-16.

Kucera, D.R. 1992. New introduction, Common pine shoot beetle. Pest Alert, United States Department of Agriculture, Forest Service, Northeastern Area, NA-PR-??-92.

LaFlamme, G. and D. LaChance. 1987. Large infection center of Scleroderris canker (European Race) in Quebec Provence. Plant Dis. 71: 1041-1043.

Langdon, Keith. 1991. Great Smoky Mountains National Park, in letter from Carroll Schell, to F.T. Campbell, December 1991.

Latin, J.D. Oregon State University Department of Entomology. Personal communications to F.T. Campbell.

Laudermilch, G. *In* Parker, Skinner, and Teillon (eds.). Proceedings, Regional Meeting: "The 1988 thrips infestation of sugar maple". 1988. Beonington, VT June 25, 1988. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington.

Ledig, F.T. 1992. Human Impacts on Genetic Diversity in Forest Ecosystems. Oikos 63: 87-108. Copenhagen 1992.

Lorimer, N. Staff Entomologist, Forest Pest Management, United States Department of Agriculture, Forest Service, Washington, D.C. Personal communication to F.T. Campbell.

MacCleery, D.W. 1992. American forests. A history of resiliency and recovery. United States Department of Agriculture, Forest Service FS-540, 59 pages.

Magasi, L.P. and S.E. Pond. 1982. European larch canker: A new disease in Canada and a new North American host record. Plant Dis. 66: 339.

May, C. 1930. Dutch elm disease in Ohio. Science 72: 142-145.

Mazzone, H.M. and J.W. Peacock. 1985. Prospects for control of Dutch elm disease—biological considerations. J. Arboriculture 11: 285-292.

McClure, M.S. 1987. Biology and control of hemlock woolly adelgid. Connect. Ag. Exp. Sta. Bull. 851. 9 pages.

McClure, M.S. 1989. Evidence of a polymorphic life cycle in the hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Ann. Entomol. Soc. Am. 82: 50-54.

McClure, M.S. 1991. Connecticut Agricultural Experiment Station, New Haven. "Control of Hemlock Woolly Adelgid." Yankee Nursery. Spring, 1991.

McGovern, T. Operations Officer, Domestic and Emergency Operations. United States Department of Agriculture, Animal and Plant Health

Literature Cited

Inspection Service. Hyattsville, MD. Personal communication to F.T. Campbell.

Mielke, J.L. 1938. Spread of blister rust to sugar pine in Oregon and California. J. For. 36: 695-701.

Miller-Weeks, M. and D. Stark. 1983. European larch canker in Maine. Plant Dis. 67: 448.

Miller, Richard. United States Department of Agriculture, Forest Service, Timber Program, Washington, D.C. Personal communication to F.T. Campbell.

Millers, Imants. United States Department of Agriculture, Forest Service Entomologist, Forest Health Protection Northeastern Area State and Private Forestry. Durham, NH. Personal communication to F.T. Campbell.

Millikan, D.F. and S.J. Stefan. 1989. Current status of the butternut, *Juglans cinera* L. Ann. Rep. North. Nut Growers Assoc. 80: 52-54.

Mitchell, R.G., G.D. Amman, and W.E. Waters. 1970. "Balsam Wooly Aphid," United States Department of Agriculture, Forest Service, Forest Pest Leaflet 118, July 1970.

Mitchell, W., P. Gibbs, and C. Marun. 1988. Flowering dogwood (*Cornus florida*): Secoon 7.5 9., U.S. Army Corps of Engineers Wildlife Resource Management Manual, Tech. Report EL-88-9, U.S. Army Engineer Waterways Exp. Sta., Vicksburg, MS. 25 pages.

Moody, B.H. 1992. Forest insect and disease conditions in Canada 1989. Forest Insect and Disease Survey, Forestry Canada, pp. 29-31.

National Academy of Sciences. 1975. Forest Pest Control. Washington, D.C.

Newcombe, G. and G.A. Chastagner. 1993a. A leaf rust epidemic of hybrid poplar along the lower Columbia River caused by *Melampsora medusae*. Plant Dis. 77: 532-535.

Newcombe, G. and G.A. Chastagner. 1993b. First report of the Eurasian poplar leaf rust fungus, *Melampsora larici-populina*, in North America. Plant Dis. 77: 532-535.

Oliver, A. Regional Director General, F.P.I. Branch, Agriculture Canada, P.O. Box 2525, New Westminster, British Columbia V3L 5A8. Personal communicaion to F.T. Campbell.

Ostrofsky, W.D., R.G. Pratt, and L.F. Roth. 1977. Detection of *Phytophthora lateralis* in soil organic matter and factors that affect its survival. Phytopathology 67: 79-84

Ostrofsky, W.D., T. Rumpf, D.Struble, and R. Bradbury. 1988. Incidence of white pine blister rust in Maine after 70 years. Plant Disease 72: 967-970.

Otvos, I.S. and F.W. Quednau. 1984. *Coleophora laricella* (Hubner), Larch Casebearer (Lepidoptera: Coleophoridae). *In* J.S. Kelleher and M.A. Hulme (eds.). Biological Control Programmes against Insects and Weeds in Canada 1969-1980, Commonwealth Agricultural Bureaux, England, 1984.

Parker, B.L., M. Skinner, and H.B. Teillon eds. 1988. Proceedings, Regional Meeong: "The 1988 thrips infestaoon of sugar maple". 1988. Bennington, VT June 23. Vt. Agr. Exp. Sta. Bull. 696 Univ. Vt., Burlington.

Payne, J.A., A.S. Menke, and P.M. Schroeder. 1975. *Dryocosmus humphisi* Yasumatsu, (Hymenoptera: Cynipidae), an oriental chestnut gall wasp in North America. U. S. Dept. Agr. Coop. Econ. Insect Report 25(49-52): 903-905.

Pelton, M.L. University of Tennessee, Department of Forestry, Wildlife and Fisheries. Personal communicaion to S.E. Schlarbaum.

Pimentel, D. 1986. "Biological Invasions of Plants and Animals in Agriculture and Forestry". *In* Mooney, H.A. and J.A. Drake (eds.). Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag. New York.

Pirone, P.P. 1980. Parasitic fungus affects region's dogwood. New York Times. New York, 24 February, 1980. pp. 34, 37.

Prey, F.J. and J.E. Kuntz. 1982. The distribution and Impact of butternut canker. *In* Black walnut for the future. USDA For. Serv. Gen Tech. Rep. NC-74. pp. 23-26.

Quimby, J. 1990. Historical summary of pear thrips in Pennsylvania. *In* Parker, B.L., M. Skinner, S.H. Wilmot and D. Souto (eds.). Pear Thrips Research and Management: Current Methods and Future Plans. Vermont Ag. Exp. Sta. Bull. 697, p. 27.

Redlin, S.C. 1991. *Discula destructiva* sp. Nov., cause of dogwood anthracnose. Mycologia 83: 633-642.

Renlund, D.W. (ed.). 1971. Forest pest conditions in Wisconsin. Wis. Dept. Nat. Res. Ann. Rep. 53 pages.

Rhea, J.R. United States Department of Agriculture, Forest Service. Forest Pest Management. Asheville, North Carolina. Personal communicaion to S.E. Schlarbaum.

Riker, A.J., T.F. Kouba, W.H. Brener, and L.E. Byam. 1945. White pine selectoons tested for resistance to blisterrust. J. For. 41: 753-760.

Roth, L.F., R.D. Harvey, Jr., and J.T. Kliejunas. 1987. Pot Orford-Cedar Root Disease, United States Department of Agriculture, Forest Service, R6 FPM-PR-294-87, 1987.

Ryan, R.B. 1990. Evaluation of biological control: introduced parasites of larch casebearer (Lepidoptera: Coleophoridae)

Literature Cited

in Oregon. Environ. Entomol. 19: 1873-1881.

Ryan, R.B., S. Tunnock, and F.W. Ebel. 1987. The larch casebearer in North America. J. For. 85: 33-39.

Santamour, F.S. Jr., A.J. McArdle, and P.V. Strider. 1990. Tests for genetic barriers to anthracnose of flowering dogwood. Am. Nurseryman. 171: 83-84.

Schlarbaum, S.E. 1989. Returning the American chestnut to eastern North America. Proc. Southern Appalachian Mast Management Workshop, pp. 66-70.

Schooley, H.O., J.W.E. Harris, and B. Pendrel. 1984. *Adelges picese* (Ratz.), Balsam Woolly Adelgid (Homoptera: Adelgidae). *In* J.S. Kelleher and M.A. Hulme (eds.). Biological Control Programmes against Insects and Weeds in Canada 1969-1980, Commonwealth Agricultural Bureaux. England, 1984.

Setliff, E.C., J.A. Sullivan, and J.H. Thompson. 1975. *Scleroderris lagerbergii* in large red and Scots pine trees in New York. Plant Dis. Rep. 59: 380-381.

Shigo, A.L. 1964. Organism interactions in the beech bark disease. Phytopathology 54: 263-269.

Shigo, A.L. 1972. The beech bark disease today in the northeastern United States. J. For. 70: 286-289.

Skilling, D.D., B. Schneider, and D. Fasking. 1986. Biology and Control of Scleroderris Canker in North America. United States Department of Agriculture, Forest Service North Central Forest Experiment Station. Research Paper NC-275. 18 pages.

Smith, Dr. Richard, United States Department of Agriculture, Forest Service, Forest Insect and Disease Research, Washington, D.C. Personal communications to F.T. Campbell.

Spaulding, P. and P.V. Siggers. 1927. The European larch canker in America. Science 66: 480-481.

Stevens, George. Chief, Department of Forestry and Horticulture, Connecticut Agricultural Experiment Station. 123 Huntington Street, New Haven, CT 06511. Personal communications to F.T. Campbell.

Stipes, R.J. and R.J. Campana (eds.). 1981. Compendium of elm diseases. Am. Phytopath. Soc., St. Paul, Minn. 96 pages.

Swank, W.T., J.B. Waide, D.A. Crossley, Fr., and R.L. Todd. 1981. Insect defoliation enhances nitrate export from forest ecosystems. Oecologia 51: 297-299.

Swank, W.T. United States Department of Agriculture, Forest Service Coweeta Hydrologic Laboratory; and F.D. Smith, United States Department of Agriculture, Forest Service Southeastern Forest Experiment Station. Personal communication to F.T. Campbell.

Tegethoff, A.C. 1965. Resurvey for European larch canker in Essex County, Massachusetts, 1965. Plant Dis. Rep. 49: 834.

Thor, E. 1976. Tree Breeding at the University of Tennessee 1959-1975. Univ. Tenn. Ag. Exp. Sta. Bull. 554. 48 pages.

Townsend, A.M. and F.S. Santamour, Jr. 1993. Progress in the development of disease resistant elms. *In* M.V. Sticklen and J.L. Sherald (eds.). Dutch Elm Disease Research: Cellular and Molecular Approaches. Springer Verlag. New York. pp. 46-50.

Tunnock, S. and R.B. Ryan. 1983. "Larch Casebearer in the Western Larch." United States Department of Agriculture, Forest Service. Forest Insect and Disease Leaflet 96, Revised September 1983.

Tunnock, S., R.E. Denton, C.E. Carlson and W.W. Janssen. 1969. Larch casebearer and other factors involved with deterioration of western larch stands in northern Idaho. United States Department of Agriculture, Forest Serv. Res. Pap. INT-68. 10 pages.

Twery, M.J. 1987. Changes in vertical distribution of xylem production in hardwoods defoliated by gypsy moth. Ph.D. thesis, Yale Univ., New Haven, CT., 96 pages.

Twery, M.J. 1990. Effects of defoliation by gypsy moth. USDA gypsy moth research review, pp. 27-34.

United States Department of Agriculture. Miscellaneous Publication #1426, 1985.

United States Department of Agriculture, Animal and Plant Health Inspection Service. 1991. An Efficacy Review of Control Measures for Potential Pests of Imported Soviet Timber. Miscellaneous Publication No. 1496, September, 1991.

United States Department of Agriculture, Forest Service. 1984. Your nation's timber. Problems and Opportunities. United States Department of Agriculture, Forest Service, Miscellaneous Publication Number 1440, 23 pages.

United States Department of Agriculture, Forest Service. 1991a. Briefing paper #FIDR-7, March 8, 1991.

United States Department of Agriculture, Forest Service. 1991b. Pest Risk Assessment of the Importation of Larch from Siberia and the Soviet Far East, Miscellaneous Publication No. 1495, September, 1991.

United States Department of Agriculture, Forest Service. 1992. Pest Risk Assessment of the Importation of *Pinus radiata* and Douglas-fir Logs from New Zealand, Miscellaneous Publication No. 1508, October 1992.

Literature Cited

United States Department of Agriculture, Forest Service. 1993. Pest Risk Assessment of the Importation of *Pinus radiata*, *Nothofagus dombeyi*, and *Laurelia philippiana* Logs from Chile. Miscellaneous Publication No. 1517. September 1993. 248 pages.

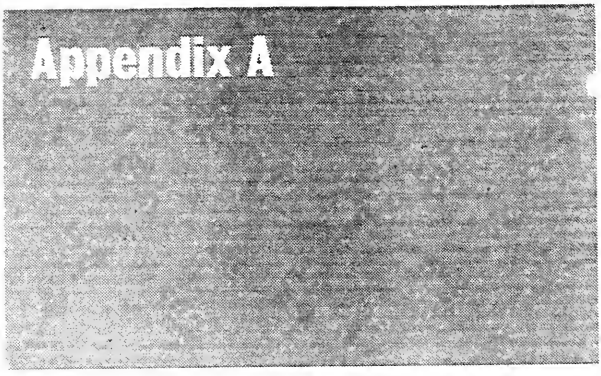
United States Department of Agriculture, Forest Service internal paper, "Biodiversity Research in Forest and Insect Disease Research."

United States Department of Agriculture Forest Service and Animal and Plant Health Inspection Service 1993 National Gypsy Moth EIS Team. Caterpillar Courier. October 1993.

Weseloh, R.M. and T.G. Andreadis 1992. Mechanisms of transmission of the gypsy moth (Lepidoptera: Lymantriidae) fungus, *Entomophaga mamaga* (Entomophthorales: Entomophthoraceae) and effects of site conditions on its prevalence. Environ. Entomol 21: 901-906

Windham, M.T. Department of Entomology and Plant Pathology, The University of Tennessee, Knoxville, Tennessee. Personal communication to S.E. Schlarbaum.

Zobel, D.B., L.F. Roth, and G.M. Hawk, 1985. Ecology, Pathology, and Management of Port-Orford-Cedar (*Chamaecyparis lawsoniana*). United States Department of Agriculture Forest Service. Pacific Northwest, General Technical Report. PNW-184



Summary of Statutes (Laws and Treaties) Governing Introductions of Alien Species Which May Attack Native Tree Species

International Plant Protection Convention (IPPC) (1951)
[Article 14 of the Constitution of the Food and Agriculture Organization of the United Nations] establishes international system under which inspections and quarantines are implemented to prevent dissemination of pests affecting plant resources.

Federal Plant Pest Act (1957) [7 U.S.C. §§ 150aa-150jj]
prohibits knowing importation or interstate transportation (except with a permit issued by the Secretary of Agriculture) of any plant "pest"; "pest" is defined as any living stage of invertebrates, bacteria, fungi, parasitic plants, viruses, infectious substances, etc., "which can directly or indirectly injure or cause disease or damage in *any* plants or parts thereof, or any processed, manufactured, or other products of plants" [emphasis added] .

Organic Act (1944) [7 U.S.C. §§ 147a-147e]
authorizes the Secretary of Agriculture, alone or in cooperation with the states or local jurisdictions, farmers' associations, governments of Western Hemisphere countries, and international organizations, to detect, eradicate, control, or retard the spread of plant "pests." (See definition of "pest" under the Federal Plant Pest Act, above.)

Plant Quarantine Act (1912) [7 U.S.C. §§ 151-164a, 167]
authorizes the Secretary of Agriculture to regulate imports or interstate shipments of nursery stock or other plants and plant parts and propagules when necessary to prevent introduction of injurious plant diseases and insect pests.

Agricultural Quarantine Enforcement Act (1989)
prohibits the shipping of any plant, fruit, vegetable or other matter quarantined by the Department of Agriculture via first-class mail; search warrants required to open packages.

Forest & Rangeland Renewable Resources Research Act (1978) [16 U.S.C. § 1642]
authorizes the Secretary of Agriculture to conduct research and experiments to obtain, analyze, develop, demonstrate, and disseminate scientific information about protecting and managing forests for a multitude of purposes; § 1642(a)(3) specifies protecting vegetation, forest, and rangeland resources from insects, diseases, noxious plants, animals, air pollutants, and other agents.

§ 1642(b) requires the Secretary to maintain a current comprehensive survey of the "present and prospective conditions of and requirements for renewable resources of the forests and rangelands...and means needed to balance the demand for and supply of these renewable resources, benefits, and uses in meeting the needs of the people of the United States...."

Cooperative Forestry Assistance Act (1978) [16 U.S.C. §§ 2101, 2102, 2104]
§ 2101(a) recognizes that "efforts to prevent and control...insects and diseases often require coordinated action by both Federal and non-Federal land managers;..."

§ 2102(b) authorizes the Secretary of Agriculture to provide assistance to state foresters to develop and distribute genetically improved tree seeds and to improve management techniques aimed at increasing production of a variety of forest products, including wildlife habitat and water.

§ 2104 authorizes the Secretary to protect from insects and diseases trees and wood products in use on National forests or, in cooperation with others, on other lands in the U.S.; such assistance may include surveys and determination and organization of control methods. Programs on non-federal lands can be instituted only with the consent of, and with a contribution of resources from, the owner. The Secretary may also prescribe other conditions for such cooperative efforts.

Executive Order 11987 (1977)
directs federal agencies to restrict the introduction of exotic species into natural ecosystems under their jurisdiction and to encourage states to do the same; directs the Secretaries of Interior and Agriculture to restrict the introduction into any natural system of animals or plants designated as injurious or noxious under the Lacey Act and Federal Noxious Weed Act.

Appendix B
Tree Species Mentioned in This Report

Deciduous	
Allegheny chinkapin	*Castanea pumilla* Mill
American chestnut	*Castanea dentata* (Marsh.) Borkh
American elm	*Ulmus americana* L.
red or slippery elm	*Ulmus rubra* Muechl.
oaks	*Quercus* spp.
sugar maple	*Acer saccharum* Marsh.
butternut or white walnut	*Juglans cinera* L.
black walnut	*Juglans nigra* L.
American beech	*Fagus grandifolia* Ehrh.
European beech	*Fagus sylvatica* L.
Chilean beech or coigue	*Nothofagus dombeyi* (Mirb.) Oerst.
flowering dogwood	*Cornus florida* L.
Pacific dogwood	*Cornus nuttallii* Aud.
Chilean tepa	*Laurelia philippiana* Looser
black cottonwood	*Populus trichocarpa* Torr. & Gray
quaking aspen	*Populus tremuloides* Michx.
Conifers	
pines	*Pinus* spp.
eastern white pine	*Pinus strobus* L.
western white pine	*Pinus monticola* Dougl. ex D. Don
sugar pine	*Pinus lambertiana* Dougl.
whitebark pine	*Pinus albicaulis* Engelm.
southwestern white pine	*Pinus strobiliformis* Engelm.

limber pine	*Pinus flexilis* James
Rocky Mountain bristlecone pine	*Pinus aristata* Engelm.
loblolly pine	*Pinus taeda* L.
red pine	*Pinus resinosa* Ait.
jack pine	*Pinus banksiana* Lamb.
ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Jeffrey pine	*Pinus jeffreyi* Grei. & Balf.
lodegepole pine	*Pinus contorta* Dougl. ex Loud.
Monterey pine (radiata pine)	*Pinus radiata* D. Don
Siberian pine	*Pinus siberica* Ledeb.
Scotch pine	*Pinus sylvestris* L.
Siberian Scotch pine	*Pinus sylvestris mongolica* Litv.
coastal Siberian pine	*Pinus koraiensis* Sieb. et Zucc.
firs	*Abies* spp.
balsam fir	*Abies balsamea* (L.) Mill.
northern bracted balsam fir	*Abies balsamea* (L.) Mill. var. *phanerolepsis* Fern.
Fraser fir	*Abies fraseri* (Pursh.)
bristlecone fir	*Abies bracteata* D. Don
subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
spruce	*Picea* spp.
red spruce	*Picea rubens* Sarg.
eastern hemlock	*Tsuga canadensis* (L.) Carr.
larch	*Larix* spp.
eastern larch or tamarack	*Larix laricina* (Du Roi) K. Koch
western larch	*Larix occidentalis* Nutt.
Siberian larch	*Larix sibirica* Ledeb.
Chinese pseudolarch or golden larch	*Pseudolarix amabilis* (Nelson) Rehder
Port-Orford-Cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.

Sources

Burns, R.M. and B.H. Honkala, tech. words. 1990. Silvics of North America. Volume 1. Conifers. Agricultural Handbook 654. USDA, Forest Service, Washington, D.C. Vol. 1, 675p.

Burns, R.M. and B.H. Honkala, tech. words. 1990. Silvics of North America. Volume 2. Hardwoods. Agricultural Handbook 654. USDA, Forest Service, Washington, D.C. Vol. 2, 877p.

Burns, R.M. and B.H. Honkala. 1976. Atlas of United States Trees. Volume 4. Minor easter hardwoods. Agricultural Handbook 654. USDA, Forest Service, Washington, D.C. 1342, 17p, 230 maps.

Little, E.L. Jr. 1976. Atlas of United States Trees. Volume 3. Minor western hardwoods. U.S.D.A. Misc. Publ. 1314. 13 p. 290 maps.

United States Department of Agriculture, Forest Service. 1993. Pest Risk Assessment of the Importation of *Pinus radiata, Nothofagus dombeyi,* and *Laurelia philippiana* Logs from Chile. Miscellaneous Publication No. 1517. September 1993. 248 pages.

Appendix C Arthropods Mentioned in This Report

smaller European elm bark beetle	*Scolytus multistriatus* (Marsham)
(native) elm bark beetle	*Hylurgopinus rufipes*
bark beetle introduced in Chile	*Hylurgus ligniperda* (F.)
spruce bark beetle	*Ips typographus* L.
spruce beetle	*Dendroctonus rufipennis* Kirby
European bark beetle	*Tomicus piniperda* (L.)
gypsy moth	*Lymantria dispar* (L.)
nun moth	*Lymantria monacha* L.
larch casebearer	*Coleophora laricella* (Huebner)
winter moth	*Operophtera brumata* (L.)
balsam woolly adelgid	*Adelges piceae* (Ratzeburg)
hemlock woolly adelgid	*Adelges tsugae* Annand
pine bark adelgid	*Pineus strobi* (Hartig)
red pine adelgid	*Pineus boernen* Annand
beech scale	*Cryptococcus fagisuga* Lindinger
elongate hemlock scale	*Fiorinia externa* Ferris
circular hemlock scale	*Nuculspis tsugae* (Marlatt)
European pine sawfly	*Diprion similis* (Hartig)
European pine sawfly	*Neodiprion sertifer* (Geoffroy)
pear thrips	*Taeniothrips inconsequens* (Uzel)
basswood thrips	*Thrips calcaratus* Uzel
woodwasps	*Sirex* spp.; S. *noctilio* F.
chestnut gall wasp	*Dryocosmus kuriphilus* Yasumatsu
European spruce sawfly	*Gilpinia hercyniae* (Hartig)
Asiatic oak weevil	*Cyrtepistomus castaneus*

pine wood nematodes	*Bursaphelenchus mucronatus* Mamiya & Enda *B. kolymensis* Korentchenko
braconid that parasitizes larch casebearer	*Agathis pumila* Latrielle
euplophid	*Chrysocharis laricinellae* (Huebner)
parasite of winter moth	*Cyzenis albicans* Robineau-Desvoidy
parasite of winter moth	*Agrypon flaveolatum* (Gravenhorst)
beetle that attacks beech scale	*Chilocorus stigma* (Say)

United States Department of Agriculture, Forest Service. 1993. Pest Risk Assessment of the Importation of *Pinus radiata, Nothofagus dombeyi,* and *Laurelia philippiana* Logs from Chile. Miscellaneous Publication No. 1517. September 1993. 248 pages.

Appendix D
Fungi and Disease Pathogens Mentioned in This Report

chestnut blight	*Cryphonectria parasitica* (Murr.) Barr (= *Endothia parasitica* (Murr.) And. & And.)
Dutch elm disease	*Ophiostoma ulmi* (Buis.) Narruf. (= *Ceratocystis ulmi* Buis.) C. Moreau or = *Ceratostomella ulmi* Buisman)
white pine blister rust	*Cronartium ribicola* J.C. Fisch.
scleroderris canker	*Ascocalyx abietina* (Lagerberg) Schlaepfer. (= *Scleroderris lagerbergii* (Lagerberg) Gremmen) (= *Gremmeniella abietina*)
European larch canker	*Lachnellula* (= Dasyscypha) *willkommii* (R. Hartig) Dennis (= *Dasyscypha willkommii* (R. Hartig) Rehm)
melampsora leaf rust	*Melampsora larici-populina* Klebahn & *M. medusae* Thuem. f.sp. *deltoidae*
butternut canker	*Sirococcus davigignenti-juglandacearum* Nair, Kostichka, & Kuntz
beech bark disease	*Nectria coccinea* (Por.:Fr.) Fr. var. *faginata* Lohman, A. M.Watson, and Ayers
beech bark disease	*Nectria galligena* Bres. in Strauss.
dogwood anthracnose	*Discula destructiva* Redlin
Port-Orford-Cedar root disease	*Phytophthora lateralis* Tucker & Milbrath
ink disease	*Phytophthora cinnamomi* Rands
Annosus root disease	*Heterobasidion annosum* (Fr.:Fr.) Bref. (= *Fomes annosus* (Fr.:Fr.) Cooke

one of fungi associated with Siberian spruce beetle	*Ophiostoma polonica*
fungus on Siberian pines, fir, spruce introduced in New Zealand	*Amylostereum areolatum*
fungus on Monterey pine, eastern white pine, loblolly pine	*Leptographium truncatum* (= *L. lundbergii*)
diplodia shoot blight	*Sphaeropsis sapinea* (Fr.:Fr.) Dyke & Sutton in Sutton. (= *Diplodia pinea* (Desnaaz.) J. Kickx fil.)
fungus which attacks gypsy moth	*Entomophaga maimaiga* Humber, Shimazu & Soper
"Bt" fungus which attacks gypsy moth	*Bacillus thuringiensis* Berliner
fungus that parasitizes *Nectria*	*Nematogonum ferrugineum* (Pers.) S.J. Hughes

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL # of pages ▸ 1

To	From
Jeff Horwath	Robert Smith
Dept./Agency	Phone #
Fax #	Fax #

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

United State

In Reply Refer To:
FWS/TE/93-3428

DEC 1993

Mr. Tom Cannon
Chairman, Maui County
Cultural Resources Commission
250 South High Street
Wailuku, Hawaii 96793

Dear Mr. Cannon:

Your August 5, 1993, letter to Secretary Babbitt, regarding protecting Hawaii's environment from non-native species, has been referred to the U.S. Fish and Wildlife Service (Service) for response.

Your comments regarding the impact of nonindigenous species on Hawaii's unique environment are most appropriate. The number of threatened and endangered species in Hawaii exceeds that in any other State, and the introduction of alien species is a significant factor. All Hawaiian plants listed under the Endangered Species Act are impacted by introduced ungulates, insects, and plants. All listed bird species in the State are endangered or threatened by introduced mosquitoes that carry avian diseases, introduced mammalian predators that prey on the birds, introduced plants that take the place of the native species with which the birds evolved, introduced birds that act as competitors and carriers of disease, and introduced ungulates that destroy native habitat. For these reasons, the Service supports a stringent inspection requirement for wildlife and plants entering Hawaii.

The Service is responsible for inspecting wildlife and some plants imported into or exported from the United States, including several injurious species. We have a team of wildlife inspectors at the Honolulu International Airport to conduct these wildlife import-export inspections. The Service does not have statutory authority to inspect flights from the United States mainland to Hawaii, except in instances involving a required permit (e.g., transporting injurious wildlife under the authority of a Lacey Act permit or transporting an endangered or threatened species in interstate commerce under the authority of an Endangered Species Act permit).

The U.S. Department of Agriculture (USDA) has the authority to inspect shipments for agricultural pests only. The current practice of inspecting all luggage leaving Hawaii for the mainland may have been brought about by the fruit fly threat to mainland agriculture. Although California is certainly a major destination point from Hawaii, all luggage headed for the mainland, regardless of the destination State, is inspected. The U.S. Customs Service also supports the efforts of the USDA, the Service, and the State of Hawaii by being watchful for imported plants, animals, and soil.

The State of Hawaii does have the authority to inspect incoming luggage, cargo, and mail for plant and animal pest species, and customarily each State regulates plants and animals entering or leaving its borders. As you mention, all arriving passengers must complete a form delineating plant and animal species they are bringing into Hawaii. Except for first class mail, which States have no authority to inspect or open, Hawaii inspects luggage, cargo, and mail for plants and animals. Currently, Hawaii uses four dogs to conduct inspections. One dog is trained to detect only brown tree snakes; three other dogs are cross-trained for different animal and plant species. In addition, the State has a mobile X-ray machine used randomly to inspect incoming luggage.

The State of Hawaii, USDA, Service, and the U.S. Postal Service are working together to study ways to enhance inspection methods in Hawaii. The State plant quarantine administrator supports providing more general authority to the USDA to inspect for any biological entity, not just agricultural pests. The Service would support such legislation and any stronger measures the State can implement. As you point out in your letter, the need is critical.

We encourage you to contact the Federal and State departments of agriculture to express your concerns, as these agencies would be responsible for implementing stricter inspection measures. If we can provide any further information regarding the impact of alien species on Hawaii's native species, please contact Robert Smith, Field Supervisor, Hawaii State Office, at 808-541-2749. We appreciate your interest in protecting Hawaii's unique flora and fauna.

Sincerely,

RICHARD N. SMITH

[redacted] DIRECTOR

cc: FWS/Region 1
Field Supervisor, Honolulu, Hawaii
6229-MIB-ES (1)
3012-MIB-FWS/CCU
3012-MIB-FWS/Directorate Reading File
3012-MIB-FWS/DDChron
3024-MIB-FWS/AES Reading File
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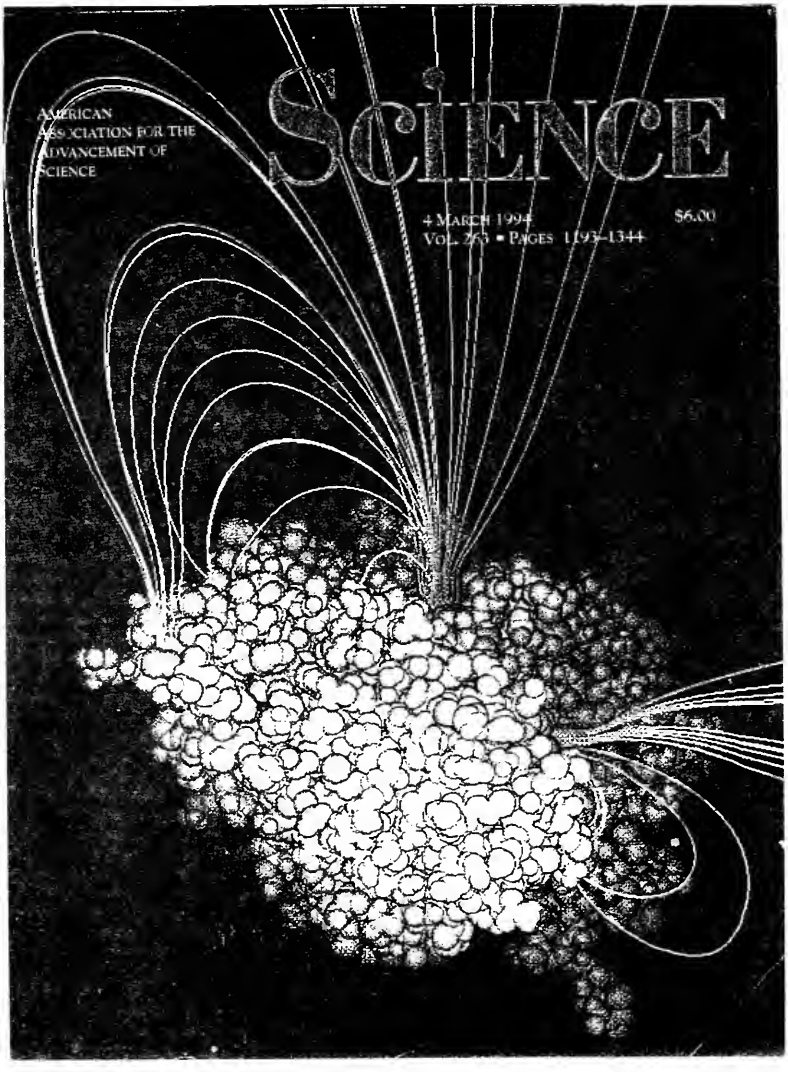
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while Americans get their information from TV, they don't necessarily trust that medium: They place the highest trust in doctors, articles by scientists, and reports from the National Institutes of Health, and descending levels of trust in newsmagazines, TV news, newspapers, and TV talk shows.

Not surprisingly, the single most powerful influence on scientific literacy was education. Ranking second was regular reading of magazines and newspapers. Age showed up as an independent influence: People over 65 had a poorer grasp of biomedicine than younger people, even when other factors such as education were held constant. That is "problematic," says Pifer, since older people are more likely to need biomedical knowledge to deal with their own health problems.

The overwhelming message of the study, says Miller, is that "education drives the system" of understanding science. He adds that "in order to change...the proportion of Americans who understand scientific inquiry, we must do it in our schools. If we miss that boat, we aren't going to change very much."

–M.B.

Flood Flexes Its Mussels

A new and unlikely item has been added to the list of problems stemming from the Great Flood of 1993, which soaked the midwestern United States: zebra mussels. As climatologist Stanley Changnon of the Illinois State Water Survey explained at the AAAS meeting, the flood moved great numbers of these destructive mollusks down the Illinois River almost to the point where it joins the Mississippi. And while the impact of the mussel migration may pale in comparison to 50 lives lost, 17 million acres submerged, and transportation systems crippled, Changnon warned that the spread of the zebras isn't a trivial problem. "This may turn out to be truly an ecological disaster," he said.

This disaster is one aquatic biologists have feared, though they didn't expect it so soon. The tiny, striped European Zebra mussels (*Dreissena polymorpha*) were first found on U.S. shores in 1988, probably hitchhiking into Lake St. Claire on a ship from Europe. The problem with the invaders is that they breed quickly and live in dense clumps, clogging pipes that carry water to cool ship engines and power plant condensers. In addition, they glom onto and destroy native mussels, clams, and snails—and deplete water oxygen levels, threatening all the marine life in areas they infest.

Until recently, the zebra invasion hadn't advanced all that far: The zebras have largely been confined to the Great Lakes and been found mostly in baseball-sized clumps. But in August 1993, divers for the Illinois Natural History Survey (INHS), a state-run sister agency of Changnon's Water Survey, found them carpeting the Illinois River 300 miles downstream of Chicago, 5 miles from where the river merges with the Mississippi. The carpet was 2 inches thick and contained an estimated 94,000 mussels per square meter—in a spot where fewer than 1000 per square meter had been found the year before. "There hasn't been an explosion like this yet, even upstream," says INHS's Richard Sparks, an aquatic ecologist. This means that the critters are now poised to overrun the Mississippi itself.

A few lines of evidence lead Changnon and Sparks to believe that the masses of foreign shellfish were washed downstream by the flood. For one thing, populations found in the Illinois River closer to Chicago's Lake Michigan, the likely source, were not as dense as the populations downstream near the confluence of the Illinois and the Mississippi. This suggests that heavy rains carried a "pulse of larvae" downstream, where they settled on the bottom. In keeping with this theory, the mussels found downstream were smaller than the ones found upstream.

Preliminary evidence gathered by INHS suggests the zebras may already be depleting oxygen levels in the Illinois River. Sparks says aquatic life is stressed when oxygen levels fall to less than 5 parts per million, and already levels as low as 3.2 have been found in areas heavily infested with zebras. "One of the most dramatic effects is they could wipe out native species of mussels and snails," says Sparks. The oxygen depletion, Sparks argues, could also have "drastic" effects on sewage treatment plants that are permitted to dump oxygen-depleting organic wastes into the river. If these plants are forced to cut back on the wastes they can discard, he reasons, the increased costs will be passed on to consumers.

Water sign. The Great Flood of 1993 seems to have spread the zebra mussels downstream.

To prevent such consequences, INHS has proposed a scheme to slow zebra mussel migration. If larvae do not float downstream and repopulate the mats of mussels now in the Illinois River, they will naturally die out in 4 to 5 years. One way larvae could be exterminated upstream is by warming the water in the canal system that links the Great Lakes to the Illinois River at Chicago. INHS proposes heating the water in the canal system with waste heat from municipal and industrial sources. Though this strategy will not prevent existing populations from sending larvae further downstream in the Illinois and into the Mississippi, INHS believes the overall damage could be significantly lowered by breaking the chain.

If nothing is done to slow the zebra mussel migration, INHS predicts hordes of larvae will float downstream in the next 2 years, carpeting much of the Illinois River and some of the Mississippi. And if that happens, the Great Flood of 1993 will become greater still, as it continues to wreak havoc in the unlikely form of a striped freshwater invader that displaces everything in its path.

–Jon Cohen

Quantum Baseball With Lasers

Physical chemist Kent Wilson of the University of California, San Diego, refers to his work as "controlling the future of matter." In his talk at the AAAS meeting, he used a photo of Babe Ruth to explain this enigmatic phrase, saying that when the baseball star wanted to control the future of the baseball—say, to make it clear the right field fence at Yankee Stadium—he applied just the right driving force with the bat. Wilson is trying to do something similar, not with baseballs but with the denizens of the microworld: atoms and molecules. And his tool is nothing as crude as 36 ounces of hickory or ash—it's a laser system producing precisely crafted pulses.

Ever since the invention of lasers, 30 years ago, researchers have wanted to use them to control chemistry. But all attempts so far have failed, because energy applied to a particular bond would leak to other bonds in a molecule, explains Wilson's Princeton colleague, chemical physicist Warren Warren. It didn't matter how finely tuned the laser pulses were, says Warren, "we couldn't do anything that can't be done with an ordinary bunsen burner." As a result, many people still consider laser-controlled chemistry a pipe dream or a joke, he adds.

But several recent advances have made this idea seem less whimsical. The first came in the mid-1980s, when scientists learned to create laser pulses short enough to deal with chemical reactions on their own time scale—a quadrillionth of a second or less. But since then, people have only used laser pulses to observe—not to control chemistry. Now, says Wilson, he is learning to use high-speed computers to calculate a laser pulse with just the right frequency-versus-time profile to achieve a specific goal, such as stretching a bond or controlling an electron's position.

Swordtails are popular aquarium fish and are established in at least seven states.

Alternatives to Release

Instead of subjecting the fish to potentially harmful environmental conditions or risking potential ecological problems by releasing it, there are alternative means for disposing of unwanted pet fish.

- Return it to a local pet shop for resale or trade.
- Give it to another hobbyist, an aquarium in a professional office, a museum, or to a public aquarium or zoological park.
- Donate it to a public institution, such as a school, nursing home, hospital, or prison.

If these options are not available, a veterinarian or fishery biologist can euthanize it (put it to sleep) with anesthetic. You can also do this at home by placing the fish in a container of water and putting it into the freezer. Because cold temperature is a natural anesthetic to tropical fishes, this is considered a very-humane method of euthanasia. A pet shop also may be able to assist you if euthanasia is the option you choose. An excellent discussion of fish euthanasia was published in the September 1988 issue of *Tropical Fish Hobbyist*. This magazine is available through pet shops or at your local library.

If you must give up your pet fish, please consider its well-being and its potential impact on the environment. Do not release it into a natural body of water.

For Further Information Contact:

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Dawn Jennings or Jim Williams

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Your local County Extension Office

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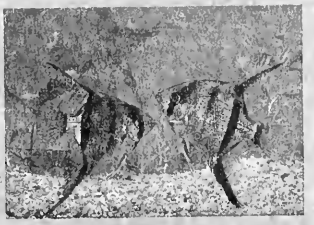
Circular 886

Don't Release Exotic Fish



U. S. Fish and Wildlife Service
Department of the Interior

Florida Cooperative Extension Service
Institute of Food and Agricultural Sciences
University of Florida
John T. Woeste, dean

Any plant or animal that is not native to the United States is considered an exotic species. Most fishes available for sale in pet shops are exotic and are imported predominantly from Central and South America, Africa, and southeast Asia. Each year, over 2,000 species, representing nearly 150 million exotic freshwater and marine fishes, are imported into the United States for use in the aquarium trade. Fish culture in Florida also results in millions of exotic fish available for sale in the industry.

Potential Problems

Unfortunately, a number of exotic fishes are released into the wild each year. Hobbyists may not be able to take their fish with them when they move, or they simply may lose interest in maintaining an aquarium. Fish may also be released if they outgrow the aquarium or if they appear to be in poor health. Whatever the reason, releasing exotic fish into local waters is not a good idea. For one thing, it may be illegal. But there are sound biological reasons, too:

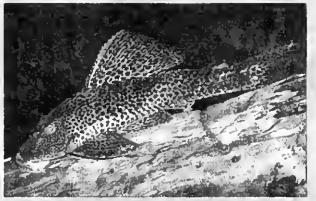
It Isn't Good for Your Pet Fish

- Released fish will be physiologically stressed upon introduction to a different environment.
- They will be susceptible to parasites and diseases.
- They might be attacked by native predators, such as larger fish, fish-eating birds, or water snakes.

Don't release your pet fish!

It Isn't Good for the Environment

- If exotic fish survive and reproduce, they are difficult, if not impossible to control or eradicate.
- They may cause changes in the existing aquatic community through competition with native species or predation on them, as well as through overcrowding or aggressive behavior.
- They may infect native fish with exotic parasites or diseases.
- An exotic may also affect the genetics of native species by hybridizing with them.
- Sole species may pose a physical or public health threat, such as piranhas and freshwater stingrays.



Armored catfish, common aquarium algae eaters, are established in Florida, Hawaii, Nevada, and Texas.

The oscar, a large, predaceous cichlid, is established in Florida and expanding its range.

Current Problems

Currently, at least 126 different species of exotic fishes have been caught in open waters of the United States, and 46 of these are known to have established breeding populations. Over half of these introductions are due to the release or escape of aquarium fishes. Because many of these fishes are native to tropical regions of the world, their thermal requirements usually prevent them from surviving in temperate areas. In the U.S., therefore, most introduced fishes have become established in Florida, Texas, and the Southwest. Examples include a number of cichlids; such as the oscar, Jack Dempsey, jewelfish, convict cichlid, Midas cichlid, and spotted tilapia; and livebearers, such as swordtails, platies and mollies, and armored catfishes. The goldfish, a native of China, is one of the few examples of a temperate aquarium species that is established throughout the U.S.

OFFICE OF TECHNOLOGY ASSESSMENT • U.S. CONGRESS

REPORT *brief*

SEPTEMBER
1993

The Nation can further cut the costly effects of non-indigenous species

Harmful non-indigenous species (NIS)—those plants, animals, and microbes that are found beyond their natural geographical range—annually cost the Nation millions to billions of dollars and cause significant and growing environmental problems, says a new report from the Office of Technology Assessment, **Harmful Non-Indigenous Species in the United States.** At the same time, beneficial NIS form the backbone of American agriculture and are important in horticulture, fish and wildlife management, biological control, and the pet industry. OTA's work takes a comprehensive look at the damaging species.

WHAT'S WHERE

The movement of plants, animals, and microbes is much like biological roulette. Once in a new environment, an organism may die. Or it may take hold and reproduce with little noticeable effect. But sometimes a new species spreads, with devastating results.

Almost every part of the country faces at least one highly damaging NIS—like the zebra mussel, gypsy moth, or leafy spurge (a weed). They affect many national interests: agriculture, industry, the protection of natural areas, and human health. The melaleuca tree, for example, is rapidly degrading the Florida Everglades system by replacing sawgrass marshes, forests, and other natural habitats with single species stands. In Hawaii, NIS are responsible for extinctions and replacements of indigenous species; they now make up at least one-half of the State's wild plants and animals.

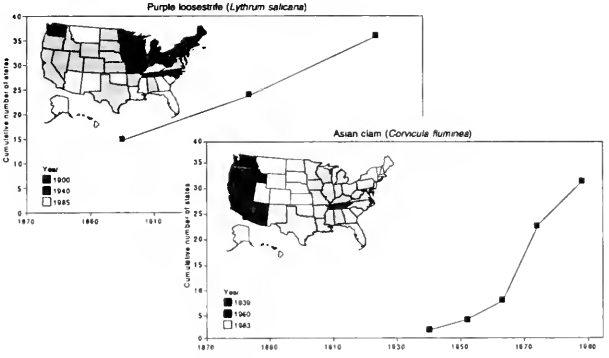
Naturally occurring movements of species into the United States are rare. Most organisms arrive with human help. Numerous NIS entered the country as unintended contaminants of commodities, packing materials, shipping containers, or ships' ballast. Others were intentionally imported as crops, ornamental plants, livestock, pets, or aquaculture species—and later escaped. For example, at least 36 of the West's 300 weeds escaped from horticulture or agriculture. A number of NIS were imported to improve soil conservation, fishing and hunting, or biological control but caused unexpected harm.

THE GOOD, THE BAD, THE "WHO KNOWS?"

Some NIS (like soybeans and most pets) are clearly beneficial; some (like gypsy moths, Russian wheat aphids, and crabgrass) are clearly harmful. Some are both, depending on location. And value is in the eye of the beholder. Purple loosestrife, for example, is an attractive garden plant and a major wetland weed.

At least 4,500 NIS of foreign origin have established free-living populations in the United States, a much larger number than were present 100 years ago. Approximately 15% of the total species trigger severe harm. Most species' economic impact is not

OTA REPORT *brief*



State by state spread of two harmful non-indigenous species

recorded. However, from 1906-1991, just 79 NIS caused documented losses of $97 billion, mostly in control costs and losses of marketable goods. A worst case scenario for 15 potentially high-impact NIS adds another $134 billion in future economic losses. This figure likely represents only a fraction of the total costs because many species and kinds of effects are uncounted. Harmful NIS also have exacted a significant toll on U.S. natural areas, ranging from wholesale changes in ecosystems to more subtle ecological alterations.

The rate of harmful introductions fluctuates in response to social, political, and technological factors. This rate does not appear to be increasing, although it is far higher than the natural rate of introductions. The cumulative number of foreign NIS in the United States, however, is climbing steadily and swiftly—creating an ever greater economic and environmental burden. Just since 1980, over 200 foreign species were first introduced or detected and at least 59 of these are expected to be harmful.

Uncertainty in predicting types and levels of risk remains a problem. Past intentional and accidental fish and wildlife introductions, for instance, have had about equal chances of turning out badly. Uncertainty can be reduced, or at least be made explicit, using methods such as risk analysis, benefit/cost analysis, environmental impact assessment, and decisionmaking protocols. The central issues for NIS and genetically engineered organisms, a special subset of this group, are the same: how to match an organism's potential for harm to pre-release scrutiny, how to treat high-risk species, and how to anticipate effects in new environments.

AN OUNCE OF PREVENTION?

For some species, prevention is the best strategy. However, port inspection and quarantine are fallible, with diminishing returns above a certain point. Also, some organisms are more easily controlled than intercepted. So aiming for a standard of "zero entry" is unrealistic, especially if prevention comes at

The Office of Technology Assessment is an analytical arm of the U.S. Congress. OTA's basic function is to help legislators anticipate and plan for the positive and negative effects of technological changes.

the expense of control. When prevention fails, rapid response is essential. So far, such quick action has prevented establishment of the Asian gypsy moth, a major threat to Pacific Northwest forests. Managing non-indigenous pests presents hard choices because funds, technology, and other resources are often limited. Sometimes this means not controlling already widespread organisms, or those for which control is very expensive, or those having lower impacts.

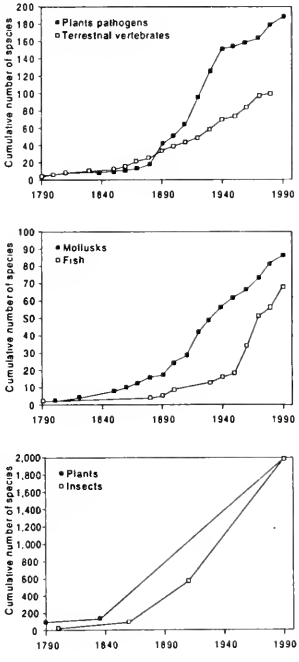
Chemical pesticides play the largest role now in containing, suppressing, or eradicating NIS and they will remain important. An increased number of biologically based technologies can be predicted. Genetic engineering will increase the efficacy of some. Those who develop biological and chemical pesticides face the same difficulties—ensuring species specificity, slowing the development of pest resistance, preventing harm to nontarget organisms, clearing regulatory hurdles, and providing profits for manufacturers.

A PATCHWORK OF POLICY

The Federal Government has responded to harmful NIS with a largely uncoordinated patchwork of laws, regulations, policies and programs. Many only peripherally address NIS, while others address the more narrowly drawn problems of the past. At least 20 Federal agencies are involved, with the U.S. Departments of Agriculture and Interior playing the largest roles. Federal laws leave both obvious and subtle gaps that most States do not fill adequately. Significant gaps exist for fish, wildlife, animal diseases, weeds, species in non-agricultural areas, and vectors of human diseases. Many of these gaps also apply to genetically engineered organisms because they are commonly regulated under the same laws.

Federal agencies manage about 30% of the Nation's lands, many with grim NIS problems. Yet management policies are often inconsistent or inadequate. Even the National Park Service, with fairly strict rules, finds invasions threatening the very characteristics for which some parks were founded.

Federal and State agencies cooperate on many programs related to agricultural pests, but their policies can also conflict, e.g., when agencies manage adjacent lands. Sometimes



The cumulative numbers of non-indigenous species in the United States

OTA REPORT *brief*

Major policy issues covered in the assessment

- A more stringent national policy
- Managing non-indigenous fish, wildlife, and other diseases
- Growing problems of non-indigenous weeds
- Damage to natural areas
- Environmental education as prevention
- Emergencies and other high priority actions
- Funding and accountability
- Gaps in legislation and regulation

Federal law preempts State law, more often regarding agriculture than fish and wildlife. Conflicts between States also occur, often without forums for resolving disputes.

State laws are relatively complete for agricultural pests but spotty for invertebrate and plant pests of nonagricultural areas. The State role is most critical for the import and release of fish and wildlife. These laws use a variety of approaches and vary from lax to exacting. While many fish and wildlife laws are weak and inadequately implemented, others present exemplary approaches. Harmful NIS have hit Hawaii and Florida particularly hard because of their distinctive geography, climate, history, and economy. Cooperative efforts have sprung up in both places. Increasingly, State and Federal agencies, nongovernmental organizations, agricultural interests, and universities see harmful NIS as a unifying threat and public education as an important tool to alleviate it.

CONGRESSIONAL CHOICES

Congress can select many ways to better protect U.S. resources. Specific actions might include amendments to the Lacey Act and the Federal Noxious Weed Act. Congress might require stricter screening for invasiveness for federally funded efforts using NIS. Congress could direct more funds to weed management on public lands and to resource management in the national parks. Congress could expand environmental education and provide Federal agencies with adequate authority for emergencies.

Imposing new responsibilities without providing money for them does not work. Entrance or user fees could fund more rigorous and scientific decisionmaking and additional control. Fines, levied on those who bring harmful NIS into the country or spread them to new States, could more closely match the real costs of publicly funded management. Federal policy cannot succeed without State help. Model State laws or national minimum standards could ensure that all States have authority to regulate harmful NIS adequately.

NIS are here to stay and many of them are welcome. Problems due to harmful ones are likely to worsen, however. Human migration and population growth, increasing trade and travel, and, possibly, climate change propel species' movements. Countervailing trends—toward stricter screening and more sophisticated control—are weaker. We can envision a future in which harmful NIS are so widespread that economic costs snowball and one place looks much like another. Or we can imagine a future in which beneficial NIS contribute much to human well-being, harmful ones are effectively limited, and indigenous species are preserved. Choosing this vision, rather than another, is ultimately a cultural and political choice—a choice about the kind of world we value and in which we want to live.

Copies of the report for congressional use are available by calling 4-9241.

Copies of the report for noncongressional use can be ordered from the Superintendent of Documents, U.S. Government Printing Office, S/N 052-003-01347-9, $21.00 each, P.O. Box 371954, Pittsburgh, PA, 15250-7954, (202) 783-3238.

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